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WASHINGTON SOILS

By R. W. Thatcher

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By R. W. Thatcher

In the fall of 1893 the Chemistry Department of this Station commenced what was planned to be an "exhaustive soil survey of the state." Work in connection with this survey has been in progress, as opportunity permitted, ever since that time. Two bulletins reporting results obtained have been issued. Bulletin No. 13, by Elton Fulmer and C. C. Fletcher, was issued in 1894, and contained a discussion of the purposes of the work and the benefits which it was hoped might accrue from it, the results of the analyses of twenty different samples of soil, a comparison of the chemical composition of some of these with typical fertile soils from other states, and a report of the analyses of eight samples of soil from what is now Benton County of this state, made by the United States Department of Agriculture. Bulletin No. 55, by Elton Fulmer, was issued in 1902. It contains a report of the results of analyses of seventy-nine soil samples, made between the date of the publication of the preceding bulletin and July 1st, 1901, and such general conclusions as seemed warranted at that time. Since the preparation of that bulletin there have been analyzed eighty-nine additional soil samples, coming in the main from different sections or different localities than those previously analyzed. It is believed that the one hundred eighty-eight samples which have been analyzed fairly represent all the different localities and different types of soil which are to be found in the state, and that the soil survey may, therefore, be considered as completed, and that a final report of its results may now be issued. This is the purpose of this bulletin, which contains a report of the analyses which have been made in

connection with the soil survey since July 1st, 1901, and a summary of the results of the whole survey. Most of the analytical work reported in this bulletin was done by the author himself. About fifteen of the samples were analyzed by Mr. H. R. Watkins, the present Assistant Chemist of the Station, to whom the author's indebtedness is hereby expressed.

OBJECTS AND METHODS OF THE SOIL SURVEY WORK.

Inasmuch as Bulletin No. 13 is now out of print, a few words as to the purpose for which this work was undertaken and methods of carrying it on may properly be given here. The variations in the topography, nature of the mother rock, climatic conditions, and other influences which have been active agencies in the formation of our soils are so great, that we have within the boundaries of the state a very large number of different kinds of soil. The variations in the types of soils of this state are probably greater than in any other state in the United States. The object of the soil survey of the state has been to accumulate as complete information concerning the chemical composition, and probable fertility to be derived thererfom, of all the varieties of soil to be found in the state, as it would be found possible to do. The possession of such data will make it possible for us to give our farmers, orchardists and investors, much valuable information both as to the probable extent and durability of the fertility of the soil in the different sections of the state, and as to the best means to increase the fertility of those soils which are not now capable of yielding wholly satisfactory crops. It is believed that the information now at hand amply repays the expense and effort necessary to secure it, and that it will become increasingly valuable as the agricultural resources are developed and more attention is given to securing increased returns from the acreages under cultivation.

In carrying out this survey, it has not been possible for this Department to send out parties to study the soil in the

different counties and to select representative samples therefrom. We have had to depend to a considerable extent upon samples sent in to us by interested persons throughout the state. Whenever such samples as were sent were accompanied by a satisfactroy description of the land from which they came, and were representative of a type of soil of considerable extent, complete analyses were made and the records of the results preserved as a part of the soil survey work. . A great many samples have been received which were of only local or private interest to the person sending them, and have been dealt with as such and are not included in this soil study. A very considerable proportion of the samples analyzed in this survey have been sent in at the request of this department and some have been secured by the chemists themselves during visits made for other purposes to the localities which they represent.

In order that the terms used and the analytical data recorded in the following pages may be more easily understood, a few words concerning the general composition of soils will be necessary.

ORIGIN AND COMPOSITION OF SOILS.

All soils are produced by the disintegration, or mechanical breaking-down, and decomposition, or chemical breaking-down, of rock. This breaking-down, or "weathering" as it is termed, is caused by the joint action of air, moisture, sudden changes of temperature, and of growing or decaying vegetation, on the rocks of which the earth's crust is composed. The action is generally slow, but is continuous and very powerful. When it has been going on long enough so that the rock is reduced to a rather fine powder, and this "rock waste" is mixed with a certain amount of decaying vegetable matter, "soil" is produced. It follows that the nature of the soil will depend largely on that of the rocks from which it originated. But the nature and the amount of vegetable matter which they contain, the extent to which they have been moved about and intermixed by wind and

water, etc., are disturbing factors which make it impossible to always definitely associate a soil with the rock which it overlays. A distinction should here be made between "soil" and "sub-soil." The latter is much more apt to be of the same chemical nature as the original mother rock of that locality. In sections of abundant rainfall, where the growth of vegetation is considerable, the character of the surface soil is much modified by the vegetable remains, and there is often a sharp line of demarcation between the soil and the subsoil. But in dry regions the differences between the soil of different depths are often scarcely perceptible.

From the above brief discussion it will be apparent that soil consists essentially of two major constituents, namely mineral matter, or "rock waste," and organic matter, or vegetable matter in various stages of decay.

The organic matter is very complex in its nature, and exists in every stage of decay from the woody fibre of growing plants to the gases which are the result of the complete decomposition of vegetable matter. In the analysis of soil a distinction is made between "volatile and organic matter," which comprises all the material which may be driven off or burned off from a soil by high heat, and includes combined water and certain gases as well as the purely vegetable matter of the soil, and "humus," or that part of the organic matter which is in certain intermediate stages of decay and may be dissolved out of the soil by dilute solutions of ammonia or other alkaline liquids. Humus is that part of the organic matter which is in the proper form to serve as a supply of plant food. It is of very great value in soils, because it not only supplies a very necessary element of plant food, nitrogen, but has also the power to attack some of the inert mineral matter of the soil and change it into forms which are available for plant food purposes. It also exerts very beneficial effects upon the physical properties of the soil because of its light, bulky form and its dark color, properties which tend to increase the power of the soil to absorb and retain heat and moisture, and to make it much more easily tillable. The influences which change organic matter

to humus are most active in well tilled soils and it will be noticed in the analyses which are reported in this bulletin that a much larger proportion of the total organic matter of cultivated soils is in this form than in the case of the "virgin", or uncultivated soils.

NITROGEN is always a constituent of the vegetable matter of the soil, although in widely varying proportions. It is an absolutely essential element of plant food, being largely consumed in the builidng up of the green growing parts of the plant, i. e., the stems and leaves, or foliage. A rank growth of dark green foliage indicates an abundance of available nitrogen in the soil, while a slow growth, of pale green color, if other conditions are suitable, indicates nitrogen hunger. None of the original rocks of the earth's crust contain nitrogen, and the supply in the soil comes wholly from decayed organic matter.

The mineral matter of the soil comprises all the material derived from the original mother rock, and exists in all degrees of fineness from coarse sand or gravel down to the finest clay particles so small as to be scarcely visible even under a powerful microscope. In making a chemical analysis, the sample of soil is first sifted through a sieve having meshes 0.5 millimeter, or 1-50 of an inch apart. This is done because it is supposed that mineral particles too large in size to pass through this sieve are too coarse to serve as a supply of plant food. All the analyses recorded in this bulletin were made on the fine earth which had been so sifted.

The mineral matter of soils ordinarily contains the following chemical elements: sodium, potassium, calcium, magnesium, iron, aluminium, maganese, sulphur, silicon, carbon, phosphorus. Of these the first seven are metallic elements, while sulphur, silicon, carbon and phosphorus are non-metals. In addition to those just named, small quantities of other elements are occasionally found, but not in sufficient quantities to give them any significance in this discussion. These elements in the soil are always united together in more or less complex compounds. These compounds al-

most invariably contain oxygen and are made up of metallic oxide (or combination of oxygen w ith a metallic element) united with a non-metallic oxide (or combination of oxygen with a non-metallic element.) Hence it is customary to determine the percenatge of the oxide of each element, rather than that of the element itself, in making an analysis of a sample of soil, as is shown in the reports of all the analyses which have been made in this laboratory. For this reason the names of these oxides rather than the names of the elements themselves, as given above, are used in the following discussion and throughout the bulletin.

In making an analysis such as has been employed for this work the soil is digested with strong hydrochloric acid (specific gravity 1.115) for ten hours at the temperature of boiling water. This treatment is believed to dissolve all the mineral matter of the soil which is in such form that it may become available as plant food. The material which is not dissolved under these conditions is undecomposed rock which has no value whatever as plant food. This is reported in the tables below as insoluble silica, although it invariably contains insoluble rock substance other than pure silica or quartz. The hydrated silica represents that part of the silica not dissolved by the acid which is soluble in a strong solution of sodium carbonate, and was originally present in the soil as clay substance, the latter being attacked by the acid and the metals in combination with it dissolved out. It is of value, therefore, as indicating the proportion of the mineral elements which are in combination as clay. The soluble silica is that part of the silica which dissolves in the acid and probably represents the amount of silicates in the soil which might, under proper conditions, be taken into plant roots has such. SILICA is of no value as plant food. Small amounts of it are found in the ash of plants, showing that it is taken up from the soil into plants, but it performs no known function in the plant tissue. The physical properties of soils are greatly affected by the amount of silica (true sand, or quartz) or clay (silicate of alumina) which it contains. Friability, porosity, and conductivity for heat are

properties of sand, while a certain amount of clay increases the water-holding capacity and capilarity of the soil.

IRON OXIDE, or iron rust, either as such or combined with water as ferric hydroxide, is present in all soils in considerable amounts, and often gives a red color to them, although if more organic matter is present the color due to iron may be obscured by the brown or black color of the humus. Plants require a small amount of iron as plant food, but it is always present in soils in far greater abundance than is ever needed by crops.

ALUMINA occurs chiefly in the form of clay (aluminium silicate). The importance of clay in a soil has already been pointed out. Alumina is not necessary to plant growth and so does not serve as plant food.

LIME is one of the most important constituents in the soil. Chemically, it serves to neutralize the organic acids produced by the decay of vegetable matter, aids the rapid transformation of vegetable matter into humus and liberates other elements of plant food from insoluble forms, thereby rendering them available for plant use. Physically, it improves the soil by rendering the clay more flocculent, thus increasing its friability and water-holding capacity, and by cementing sand grains in sandy soils, thereby increasing the water-holding capacity and capillary of the soil. Lime is also required by plants in building up cell-tissue, but only in very small amounts, hence it is usually abundant in the soil as far as its use as plant food is concerned.

MAGNESIA occurs in the soil associated with lime, and is somewhat similar in its chemical properties to it. But it does not exert the same beneficial effect on the soil as does the lime. Magnesia is used by plants, especially by cereals, being in some way connected with seed-formation. It is usually present in soils in abundance for plant uses.

POTASH is present in soils as a result of the decomposition of rocks of the feldspar type, such as orthoclase, granite and some forms of mica. It is usually found more or less loosely combined with the clay which results from the decomposition of these rocks. It is an essential element of

plant food, being connected with the building up of the carbohydrates (starches, sugars, etc.) It is, therefore, needed in considerable amounts by all crops, especially fruits and vegetables.

SODA is very similar to potash in its origin, occurence in the soil, and chemical properties. It cannot, however, perform the functions of potash in plants, and is of no value as plant food. When present in soils in forms which are soluble in water it is one of the commoner kinds of "alkali" and if in sufficient quantity is very injurious to plants.

PHOSPHORIC ACID is the form in which the element phosphorus usually occurs in soils. It never occurs as free acid but combined with iron, lime, or some other metal, phosphate of lime being the most common form. It is usually present in smaller amounts than any other of the substances mentioned above. It is a very essential element of plant food, being required for the building up of proteid matter in plants. This proteid matter is usually stored up largely in the seeds and forms an important constituent of them. Hence, phosphoric acid is directly connected with seed-production and is required in considerable amount by all crops, especially by the cereals. Because of the small amounts which are ordinarily present, soils are often deficient in phosphoric acid and are, therefore, benefitted by the application of phosphate fertilizers.

SULPHURIC ACID bears the same relation to the element sulphur that phosphoric acid does to phosphorus, and what has been said about the latter applies equally as well to sulphuric acid. It is present in soils in much smaller quantities, however, but is required in smaller amounts by plants. Hence, it is supposed to be always present in sufficient amounts to supply plant needs, although the most recent investigations seem to show that the use of sulphates as fertilizers is of more importance than has been supposed.

CARBON DIOXIDE, or carbonic acid gas, is present in soils both as the free gas and combined with lime and other metals, as carbonate of lime, etc. The gaseous form is not included in the ordinary analysis of the solid matter of soils.

The combined carbonic acid is of importance as a measure of the amount of carbonate of lime present, since it is in this form which lime exerts its most beneficial effects.

From the above discussion it will be seen that of all the elements described, four alone are necessary to be considered in connection with problems of supply of plant food, or fertility questions. The others are either non-essential to plant growth, or are always present in soils in abundance. The four constituents, lime, potash, phosphoric acid, and nitrogen, which are essential to plant growth and are likely to be insufficient in quantity in the soil are known as the "critical elements of fertility."

A study of the analytical tables recorded in this and the preceding soil bulletins shows exceedingly wide variations in the percentages of these different elements in our soils. As a means of comparison with these, the following statement of the average composition of two hundred typical fertile soils, as given by Professor Snyder, of the Minnesota Agricultural Experiment Station, in his book on "Soils and Fertilizers," is presented:

Insoluble matter -	79.95 per cent
Potash - -	0.29 per cent
Soda - - -	0.25 per cent
Lime - -	2.16 per cent
Magnesia - -	0.55 per cent
Iron Oxide -	2.68 per cent
Alumina - -	5.20 per cent
Phosphoric anhydride	0.24 per cent
Sulphuric "	0.03 per cent
Carbonic "	1.12 per cent
Volatile Matter -	7.00 per cent
Total -	99.7 per cent
Humus - -	3.35 per cent
Nitrogen -	0.29 per cent

It appears that an average fertile soil of Washington is richer in potash, about the same in phosphoric acid, and

poorer in carbonate of lime, humus and nitrogen, than the average of those reported by Prof. Snyder, which seem to have come chiefly from the prairies of the Upper Mississippi Valley.

RELATION OF SOIL COMPOSITION TO FERTILITY.

The methods of analysis employed in his work show the total amount of plant food present in the soils in forms which are dissolved by the strong acid employed. They do not at all show how much of this material is in available forms for plant uses. Unfortunately, no methods have yet been perfected which will show, with sufficient accuracy to make them even fairly conclusive, how much available plant food of the various kinds is present in a soil at any given time. The best that can yet be done, therefore, is a determination of the total acid-soluble plant food. Experience has shown, however, that it is possible to draw certain fairly definite conclusions as to the fertility or fertilizer needs of a soil from the results of such an analysis. In this connection, Professor Hilgard, the celebrated authority on soils in this country, says: "As between soils of similar character and origin, the production and durability are sensibly proportioned to the plant food percentages when the latter fall below a certain limit." With regard to the percentages of each of the critical elements of fertility, lime, potash, phosphoric acid, and nitrogen, which are necessary for satisfactory plant growth, the most complete standards which have been proposed are those of Professor Maerker, of the Halle Experiment Station, in Germany. These are given in Prof. Hilgard's new book on "Soils," page 369, as follows:

Practical Ratings of Soils by Plant-Food Percentages According to Prof. Kaerker, Halle Sta., Germany.

Grade of Soil	Potash	Phosphoric Acid	Lime Clay Soil	Lime Sandy Soil	Total Nitrogen
Poor	Below .05	Below .05	Below .10	Below .05	Below .05
Medium	.05—.15	.05—.10	.10–.25	.05–.10	.05—.10
Normal	.15—.25	.10—.15	.25–.50	.10–.20	.10—.15
Good	.25—.40	.15—.25	.50–1.00	.20–.30	.15—.25
Rich	Above .40	Above .25	Ab've 1.00	Above .30	Above .25

These estimates are in very close agreement with nearly all of those which have been suggested by other soil chemists, in all parts of the world, although different methods of analysis are used by men in different countries. In fact, the writer believes that these standards may be fairly considered as proper ones for soils throughout the humid regions of the temperate zone. In tropical regions percentages required for fertility have been shown to be much less than these, and in semi-arid districts, typical fertile soils invariably show higher percentages of the mineral ingredients of the soil. But for general purposes, the standards of Prof. Maerker may be commonly applied, and it is suggested that they be kept carefully in mind in the consideration of the analyses reported in this, and the other bulletins in this series.

RESULTS OF ANALYSES OF SOILS.

The results of the analyses of the samples of soils which have been made in connection with this survey, since those reported in Bulletin 55 were completed, follow. The samples are arranged by counties, and following each analytical table, a brief description of each sample and discussion of the results of the analysis of it are given.

SPOKANE COUNTY.

	No. 564	No. 641	No. 642	No. 643	No. 1030
Insoluble Silica	65.040	84.380	79.432	65.480	70.900
Hydrated Silica		2.920	7.776	11.626	9.540
Soluble Silica		0.108	0.040	0.580	0.122
Potash (K_2O)	0.829	0.438	0.304	0.356	0.389
Soda (Na_2O)	0.912	0.356	0.250	0.550	0.230
Lime (CaO)	7.768	0.320	0.334	0.524	0.618
Magnesia (MgO)	3.891	0.142	trace	0.398	0.295
Manganese Dioxide (Mn_2O)	none	none	none	none	none
Iron Oxide (Fe_2O_3)	4.123	3.100	3.430	4.298	3.141
Alumina (Al_2O_3)	6.928	5.335	6.655	10.826	6.582
Phosphorus Pentoxide (P_2O_5)	0.249	0.108	0.157	0.300	0.185
Sulphur Trioxide (SO_3)	trace	none	0.073	0.061	0.100
Carbon Dioxide (CO_2)	7.187	"	none	none	trace
Volatile and Organic matter	3.724	2.595	1.822	5.448	7.894
Total	100.151	99.802	100.273	100.484	99.996
Humus	1.000	0.600	0.520	1.190	3.050
Total Nitrogen	0.062	0-027	0.022	0.061	0.143
Moisture in Air-Dry Soil	2.880	0.606	0.787	1.910	2.040

No. 564 was sent in by Mr. B. O. Wing, of Spokane. It was taken from the upper part of the Little Spokane valley, representing an area which it was proposed to bring under irrigation. Mr. Wing writes that the soil shows "alkali" spots. The analysis shows the soil to be marked calcareous in nature, containing over 18 per cent of carbonates of lime and magnesia. The proportion of potash and soda is also very high—indicating the possibility of considerable amounts of alkali in the soil. Under proper irrigation, these injurious alkali salts might be successfully removed, however, and the soil is otherwise well stocked with plant food. It is somewhat low in humus and nitrogen, but this is quite characteristic of irrigated soils, and may easily be remedied by plowing under leguminous crops.

Nos. 641, 642 and 643 were sent in by Mr. Guy Stambaugh, of Elk. They were taken from a farm lying upon the divide east of the Little Spokane river, on Sec. 7-29-44 E. Nos. 641 and 624 are stiff clay loams lying at the top of the divide, while No. 643 lies lower down on the east slope. The upper soils are very deficient in humus and nitrogen, the lower soil being better supplied but still not very rich in these constituents.

No. 1030 was sent in by Mr. J. A. Yeomans, of Spokane, who writes that the sample was taken from Sec. 25-26-43 E.; that it represents a very considerable area of soil in the district known as "Five Mile Prairie," and that winter apples growing on this soil do not "color up" well, and asks for an explanation of the latter difficulty. The analysis shows the soil to be well supplied with all the essential elements of plant food; potash and iron, the two elementts which are sometimes supposed to be associated with the production of highly colored fruit, being present in ample amounts. The difficulty which Mr. Yeomans mentions is, therefore, probably due to climatic or other conditions, rather than to any lack of fertility in the soil.

STEVENS COUNTY

	No. 77	No. 78	No. 161	No. 342	No. 435	No. 436	No. 655	No. 656	No. 673	No. 1103
Insoluble Silicia	76.686	79.420	87.718	79.698	70.624	70 680				
Hydrated "	9.706	8.630	4.242	7.204	12.758	11.672	82.700	86.870	90.400	17.593
Soluble "	0.026	0.034	0.040	0.060	0.093	0.074				
Potash (K_2O)	0.492	0.225	0.074	0.162	0.193	0.229	0.412	0.320	0.336	0.099
Soda (Na_2O)	0.033	0.338	0.290	0.426	0.283	0.263	0.476	0.290	0.080	0.344
Lime (CaO)	0.741	0.741	0.400	0.350	0.506	0.494	0.640	0.590	0.499	36.009
Magnesia (MgO)	0.150	0.239	0.234	0.175	0.374	0.602	1.218	0.469	0.515	0.684
Manganese Dioxide (MnO_2)	none	none	none	trace	none	none	trace	none	none	trace
Iron Oxide (Fe_2O_3)	2.384	2.142	1.246	2.308	2.563	2.976	3.370	3.380	2.349	0.661
Alumina (Al_2O_3)	5.939	5.175	2.361	5.457	6.362	6.471	4.246	4.521	3.057	0.720
Phos. Pentoxide (P_2O_5)	0.122	0.048	0.083	0.280	0.400	0.343	0.217	0.089	0.192	0.082
Sulphur Trioxide(SO_3)	none	none	none	0.034	none	none	none	none	none	0.389
Carbon Dioxide (CO_2)	"	"	trace	none	"	"	"	"	"	28.998
Vol. & Organic Matter	4.201	3.445	3.420	4.019	5.736	6.163	7.057	3.840	2.511	*14.431
	100.500	100.437	100 108	100.173	99.894	99.997	100.369	100.369	99.939	
Humus	0.890	0.465		1.590	1.930	1.970	2.950	1.410	0.920	3.380
Total Nitrogen	0.049	0.034		0.044	0.106	0.115	0.098	0.040	0.030	0.499
Water in Air-dry Soil	1.311	0.847	0.413	2.420	2.871	3.057	0.932	0.759	2.249	2.240

*Estimated by difference.

STEVENS COUNTY.

Nos. 77 and 78 are samples of surface soil and subsoil respectively, sent in by Mr. P. E. Peterson, of Camden. Mr. Peterson writes: "This soil is taken where nothing is growing, except trees all having pitch, except cedar. The ground has never been plowed and never had any manure, but fire has run over it several times. There is at present a thin covering of pine, fir, balsam fir and tamarack needles. There is no lime, minerals, or ore in this locality so far as I know. The land where this soil was taken is low and level and is apparently different from the high land soil. I plowed two acres of this land this spring and sowed it to sand vetch, but it did not grow four inches high, while vetches in my garden grew three feet high. The garden has had manure. My neighbors inform me that crops of any kind do not do well on this soil the first year after it is broke up, owing to there being too much turpentine, or pitch in the ground." The analyses show the soil to be well supplied with potash, lime and phosphoric acid, but very low in humus and nitrogen. It is probable that the difficulty in getting crops to grow on new land of this kind is due to a lack of available nitrogen. This is further shown in the beneficial effect of manure on the soil. The plowing under of some vegetable or animal matter to supply humus and nitrogen is the obvious remedy.

No. 161 is not properly a soil, but a sample of the white ashy subsoil found in layers underlying the surface soil in many places in Eastern Washington. It was sent in by Mr. Mihills, of Spokane, who writes that it was taken from his ranch in Spirit Valley, in the southeastern part of Stevens County. He states that this subsoil is covered with a rich, black loam from six to twenty-four inches in depth and asks if this subsoil is adapted to the growing of grass crops, or if it can be improved by manure or other fertilizers. Both the microscopic examination and the chemical analysis of this material show it to be a highly siliceous volcanic ash, of little value for plant food purposes. It could not possess much value to crops either chemically or physically, and the growth

of crops will depend wholly upon the nature of the overlying soil.

Samples Nos. 342, 435, 436, 655 and 673 all represent soils from the Pend d'Oreille valley taken at different localities along its course through Stevens Co.

No. 342 was sent in by Mr. W. A. Sloan, of Locke. It was taken from the S.E. quarter of Sec. 14-34-43 E. Mr. Locke writes: "The land here lies in benches rising one above the other back from the Pend d'Oreille river. This place is about five hundred feet above the river and two and one-half miles from it. This soil seems very peculiar in that it retains moisture very tenaciously, as during the past summer when it has been so dry (three months without rain) if one dug down three or four inches the soil felt quite moist. When dry it is like powder, and makes a very deep dust, and when moist it packs down quite hard yet is very easily tilled. There have been at least three forest fires burned over this ground. The last one, last summer, left a thick coating of ashes on the ground. The land has never been under cultivation." The analysis shows the soil to be well stocked with phosphoric acid, fairly well supplied with potash, lime and humus, but low in nitrogen. Mr. Locke's proposal to plow under a clover crop would be ideal treatment for this type of soil.

Nos. 435 and 436 were sent in by Mr. Chas. M. Talmadge, of Newport, who describes them as follows: "I am sending you two samples of soil from a piece of bench land south of Newport. Sample No. 1, (No. 435), is taken from a piece which has a heavy growth of fir, tamarack, pine and alder. There is very heavy growth of underbrush and vines. The soil is always moist, for the reason that water may be had at almost any point on it at a depth of from three to four feet. Sample No. 2, (No. 436,) is from adjoining land that lies about ten to fifteen feet higher and has a lighter growth of timber, mostly fir and pine. I would like very much to have the soil analyzed in hopes that some way may be discovered of taming the soil for a first crop. Garden peas sowed on this soil started out splendidly, but after they

had attained a height of about six inches they stopped growing and have since truned yellow. Other vegetables are acting the same way. Potatoes, however, show up much better and will undoubtedly return a half crop." The most noticeable difficulty with these soils is the proportion of coarse sand, gravel, etc., which they contain, No. 435 showing 26.4 per cent and No. 436 62.6 per cent of material of this kind which is too coarse to serve for plant food purposes. The fine earth of the soil, in each case, shows unusually high percentages of phosphoric acid, and a fair supply of potash, nitrogen and humus. The amount of lime is rather low, and it is probable that this, together with the poor physical condition of the soil, is responsible for the lack of available plant food as shown by the poor growth of plants on these soils.

Nos. 655 and 656 are soil and subsoil from the Pend d-'Oreille at Usk, sent in by Mr. Henry Bauer. Unfortunately, the correspondence concerning these samples has been mislaid.

No. 673 was sent in by Mr. R. X. Davis, also of Usk, who states that it represents a somewhat different type of soil from that owned by Mr. Bauer. The chief difference in the analyses of these two soils is in their humus and nitrogen content. The inorganic or mineral plant foods, potash, lime and phosphoric acid are not greatly different in the two cases, and are present in fairly liberal amounts. The supply of nitrogen in No. 673 is very low -and the soil is probably deficient in available nitrogen.

No. 1103 was sent in by Mr. S. R. Taylor, from Rockcut, in the extreme northwest corner of the county. Mr. Taylor writes: "I am sending you a sample of some soil over which I have been greatly baffled. I have tried to raise grain upon it, grain of different kinds, but to no purpose. The grain apparently sprouts quickly after first sown, and shoots up green and rank, but presently it turns yellow and then begins to burn up as if a scorching sun had blasted it, until it finally dies outright. Whether the weather is wet or dry makes no material difference with it." The analysis

shows that the material is not true soil, but an impure carbonate of lime, or marl mixed with a little soil. It contains about 66 per cent of carbonate of lime. The difficulty of producing crop is easily explained by this fact. It would be almost impossible for any considerable amount of plant food to remain in available form in such a mixture as this any great length of time.

FERRY, OKANOGAN AND CHELAN COUNTIES

	FERRY			OKANOGAN		CHELAN			
	No. 446	No. 1872	No. 1873	No. 789	No. 790	No. 158	No. 576	No. 1885	No. 1886
Insoluble Silica	77.044	77.330	73.652	63.484	82.884	82.340	63.600	81.632	78.470
Hydrated Silica	10.492	5.418	7.456	24.414	6.036	3.988	12.822	2.498	1.902
Soluble Silica	0.204	0.016	0.090	0.107	0.113	0.260	0.319	0.316	0.180
Potash (K_2O)	0.264	0.323	0.384	0.294	0.335	0.118	1.144	0.518	0.649
Soda (Na_2O)	0.235	0.201	0.220	0.392	0.449	0.435	0.341	0.233	0.220
Lime (CaO)	0.581	0.961	0.769	0.668	0.944	0.379	1.365	0.714	0.852
Magnesia (MgO)	0.548	0.262	0.216	0.162	0.319	0.301	0.897	0.186	0.522
Manganese Dioxide (Mn_2O)	none	none	none	none	none	none	trace	none	none
Iron Oxide (Fe_2O_3)	2.811	3.490	3.847	2.604	2.852	2.451	5.365	4.760	4.086
Alumina (Al_2O_3)	4.440	3.570	5.370	3.366	2.841	4.881	6.903	6.145	7.700
Phosphorus Pentoxide (P_2O_5)	0.124	0.257	0.241	0.145	0.170	0.078	0.122	0.225	0.240
Sulphur Trioxide (SO_3)	none	.068	0.024	0.025	0.072	trace	0.029	none	0.030
Carbon Dioxide (CO_2)	trace	none	none	none	none	none	none	none	none
Volatile and Organic matter	3.290	8.766	8.615	4.464	2 282	5.440	7.086	2.969	4.520
Total	100.033	100.666	100 .884	100.135	99.787	100.437	99.993	100.176	99.371
Humus	0.780	7.099	6.671	1.650	1.440	1.645	2.860	1.942	1.830
Total Nitrogen	0.040	0.262	.220	0.062	0.085	0.087	0.215	.061	.077
Moisture in Air-Dry Soil	0.218	3.388	3.770	0.908	0.890	2.920	1.870	1.650	2.232

FERRY COUNTY.

No. 446 was sent in by Mr. J. J. Charlton, of Kettle Falls. It was taken from the northwest quarter of Sec. 9-35-37 E. The soil is a very coarse gravelly upland loam, the sample containing 63.5 per cent of coarse sand, gravel, etc., and only 36.5 per cent of earth fine enough to serve as plant food. Mr. Charlton writes concerning the soil: "I have made three attempts to raise alfalfa, the third time inoculating the seed, but it is not yet satisfactory. After the present year I will have plenty of water for irrigation." The analysis shows the fine earth of the soil to be well supplied with potash, lime and phosphoric acid, but quite poor in humus and nitrogen. Taking into account the fact that the fine earth constitutes only about one-third of the soil, and that the plant food in the soil is thus greatly thinned out by the large amounts of gravel, etc., it is probable that their is a deficiency in available plant food of all kinds. Soil of this kind would have a poor water-holding capacity, and it may be that the lack of fertility is due to its inability to hold enough water for the plant needs.

Nos. 1872 and 1873 were brought to the laboratory by Mr. H. C. Wilcox, of Pullman, but were taken at his request from districts in Ferry County. No. 1872 was taken from an open bunch grass prairie three miles south of Malo. It came from unbroken sod land. It was a fine brown loam soil, with an occasional large pebble or stone, but with very little coarse sand and gravel. No. 1873 was taken from a cleared pine forest near Republic. This land has been under cultivation for a few years. The soil is a black, clay loam, containing many large pebbles from the size of a pea to that of a hens egg, but no sand or fine gravel. The analyses show both of these soils to be very rich in all the essential elements of plant food. With thorough cultivation, they should prove of very high fertility for a long time to come.

OKANOGAN COUNTY.

The two samples of soil from the Okanogan Valley were taken from land owned by the State College. They were secured at the request of the writer by Mr. Geo. A. Davis, of Ophir. No. 789 was labelled by him as "Okanogan Valley soil which has never been broken up or cultivated. Best alfalfa and fruit land in the valley." No. 790 was marked "Soil from the State College Flat. Has been cultivated two years. Last year produced thirty bushels of wheat per acre, without irrigation." No. 789 was a coarse sandy alluvial drift, containing 46 per cent of coarse sand, etc., and 64 per cent of fine earth. No. 790 was a very fine silt of the most uniform texture and the finest physical condition of any sample of soil which has ever been received at this laboratory. The two soils are both well stocked with plant food, although the proportion of nitrogen in the lower sandy soil is rather low for a grain soil.

CHELAN COUNTY.

No. 158 was sent in by Mr. J. F. VanDyke, of Leavenworth. It was taken from the Chewawa River bottom, about six miles north and east of the east end of Lake Wenatchee. It was a coarse sandy soil containing 63.2 per cent of fine earth. The pebbles in the sample were chiefly partially decomposed sandstone rock. The analysis shows the sample to be rather poorly supplied with mineral plant food, lime especially being present in unusually small amounts for a soil from East of the Cascade Mountains.

No. 576 was a sample of only partially decayed or disintegrated granite. The weathering of the rock had gone on far enough so that the pebbles of rock were very rotten and crumbled easily between the fingers, and a considerable amount of decayed vegetable matter was present so that the material could probably be classed as soil. It was sent in by Mr. H. C. Peters, of Seattle, but was taken from the southeast quarter of Sec. 14-24-17 E., a little over a mile north of

Leavenworth. Mr. Peters describes it as follows: "The property lies at the foot of a mountain in the Cascade Ridge running up some 5000 feet. The valley is a mile and a half long, by a half a mile wide and is in the valleys of the Wenatchee and Icicle Rivers. The soil seems to be very deep, twenty feet or more, and apparently is a deposit of decomposed granite washed down from the hill and forming a level plateau." The analyses show the sample to be very rich in potash and lime, and well stocked with phosphoric acid, humus, and nitrogen. Whether these ingredients are in such form that they may easily become available for plant food in sufficient quantities can only be ascertained by experimental crops, but the probability is that this will prove a very fertile soil.

Nos. 1885 and 1886 were sent in by Mr. J. F. Littoooy, manager of the Wenatchee Canal Company's orchards at Wenatchee, in response to the writer's request for representative samples of the Wenatchee fruit lands. No. 1885 represents the upper bench lands, lying at an elevation of some thirty to fifty feet above the Columbia River, and No. 1886 represents the lower bench lying between the higher land and the river bottom proper. The samples are quite similar in their chemical composition, both being very rich in potash, and well supplied with lime and phosphoric acid, and having a fair amount of humus and nitrogen. The fine earth of the lower soil is slightly richer in all the essential elements of fertility than the soil of the upper bench, but this is more than counterbalanced by the fact that it contains 44.7 per cent of coarse sand, etc., which is unavailable for plant food purposes. Both soils are amply supplied with plant food, and under proper cultivation, especially when irrigated, are capable of the very highest fertililty.

LINCOLN AND DOUGLAS COUNTIES

	LINCOLN				DOUGLAS				
	No. 741	No. 742	No. 1087	No. 1890	No. 868	No. 1024	No. 1241	No. 1242	No. 1416
Insoluble Silica	77.546	76.376		79.264	68.640	78.798	73.494	73.494	77.538
Hydrated "	5.348	6.484		3.146	10.570	6.882	11.676	10.582	8.972
Soluble "	0.254	0.256		0.265	0.064	0.460	0.447	0.154	0.898
Potash (K_2O)	0.436	0.524	0.368	0.517	0.335	0.312	0.298	0.442	0.380
Soda (Na_2O)	0.516	0.563		0.191	0.625	0.329	0.302	0 352	0.185
Lime (CaO)	0 842	0 755	0.919	0.563	5.561	1.120	0.568	0.762	0.563
Magnesia (MgO)	0.584	0.746		0.070	0 976	0.445	0.568	0.643	0.171
Manganese Dioxide (MnO_2)	none	none		none	none	none	none	none	none
Iron Oxide (Fe_2O_3)	3.844	3.560		4 879	2 645	5.290	7·715	6.963	5.198
Alumina (Al_2O_3)	6.726	6.990		6.445	3.062	4.472	1.700	2.975	3 155
Phos. Pentoxide (P_2O_5)	0.117	0.150	0.129	0.172	0.155	0.050	0.125	0.147	0.102
Sulphur Trioxide(SO_3)	0.032	0.033		0.048	0.112	none	0 017	0.024	none
Carbon Dioxide (CO_2)	none	none		none	3.952	none	none	none	none
Vol. & Organic Matter	4.329	4 323	4.897	4.808	2 898	1.450	3.338	3.881	3.672
Total	100.474	100.657		100.658	?9.595	99.808	100.248	100.419	100.834
Humus	1.815	2.385		2.103	0.890	0.380	0.990	1.280	1.280
Total Nitrogen	0.121	0.132	0.127	0.126	0 069	0.026	0.049	0.085	0.078
Water in Air-dry Soil	2.350	2.024	4.280	2.252	0 690	0.432	1.516	1.534	0.996

LINCOLN COUNTY.

Nos. 741 and 742 were sent in by Mr. Wm. L. Lauritzen, of Wilbur, who writes: "I send you herewith two samples of soil from land near Wilbur, Sec. 4-26-33 E., which I think will represent the average soil in this locality. One sample, (No. 741), is soil which has never been under cultivation and the other. (No. 742), is soil that was plowed the first time in 1886, and this year it raised a crop of thirty bushels of wheat to the acre; it never had any kind of manure, except of course the stubble and weeds plowed under when summer fallowed." These samples represent soil abundantly supplied with all the essential elements of plant food. The somewhat greater percentages of potash, phosphoric acid, and lime in the soil which has been under cultivation without manuring for twenty years are unexplainable except on the grounds of differences in the original virgin soils in the two spots from which the soil came.

No. 1087 was brought in to the laboratory by Mr. Otto Wollweber, of Reardan, who stated that the sample is typical soil of northeastern Lincoln Co. The sample was taken from Sec. 10-26-39 E. The soil has been under cultivation for twenty-one years, and has produced eighteen crops of wheat and two crops of sugar beets. A complete analysis of this sample was not made, but the percentages of the elements which were determined show it to be practically identical in composition with Nos. 741 and 742.

No. 1890 was sent in by Mr. M. T. Brislawn, of Sprague, and was selected by him as a representative sample of the Sprague wheat lands. It came from Sec. 19-22-39 E., and was taken from a high level strip where there was no possibility of any kind of sedimentation, and so represents typical unaltered soil of this district. It came from land which had been under cultivation for a few years. The results of the analysis show it to be very similar in composition to the other soils from this county. In fact, the soil throughout that part of the Big Bend country lying east of the Douglas County line seems to be very uniform in its chemical composition.

DOUGLAS COUNTY.

No. 868 is a sample of a light sandy soil containing some alkali, sent in by Mr. Ernest Peterson, of Ephrata. It was taken from his land lying about 75 rods from Soap Lake. Mr. Peterson writes: "A great part of this land is covered with salt grass. In places there was no salt grass—corn was good, seven feet tall and every stalk with one or two ears eight to ten inches long, and in some places nine ears to the hill; but where the salt grass was the corn did not grow more than five feet tall and then died out. We have had no luck with potatoes so far. The sample was taken from eight different spots to a depth of eighteen inches. It was underlaid with a hard-pan subsoil." It was found to contain 0.326 per cent of water-soluble salts or alkali, an amount somewhat higher than is tolerated by most plants. These salts were all in the form of white alkali, however, which is the least harmful form. The soil contains a good supply of potash and phosphoric acid, and a large excess of lime amounting to almost 10 per cent of carbonate of lime. The supply of humus and nitrogen is low. Mr. Peterson writes that the land cannot be flooded for the removal of the alkali, and a heavy treatment with rich manure was suggested as the best remedy for the alkali and at the same time an improvement in the supply of humus and nitrogen in the soil.

No. 1024 was a sample of the very sandy soil of that part of Douglas County lying south of the line of the Great Northern Railroad. It was sent in by Mr. H. W. Olney, of Spokane, but was taken from land lying fifteen miles southeast of Winchester. The analysis shows this sandy soil to be well supplied with potash and an abundance of lime. It has a low percentage of phosphoric aicd and only very slight amounts of humus and nitrogen. With conditions very favorable for the availability of the plant food in the soil it will probably produce crops for a time if a sufficient supply of water can be had, but the humus and nitrogen are present in such small quantities that they will have to be very materially built up before any very permanent fertility is possible.

Nos. 1241 and 1242 were sent in by Mr. F. E. Weston, of the Washington Land Co., of Waterville, as representative samples of the wheat lands of the Waterville district. Mr. Weston writes concerning the samples: "Sample No. 1 (Laboratory No. 1241) was taken from the southwest quarter of Sec. 10-25-24 E., and is virgin soil. The land is situated about fifteen miles from the Columbia River and the soil in this locality is considerably lighter than that along the breaks of the river, and the best results are obtained from winter wheats, as spring wheat is apt to burn on this soil. Sample No. 2 (Laboratory No. 1242) was taken from the northeast quarter of Sec. 2 -25-22 E. This soil is considered as strong as any in the Waterville district and spring wheat does better than winter." The analyses show the reason for the greater fertility of the second sample, since it contains more of each of the necessary elements than does No. 1. Both of these are well balanced soils, but will probably need replenishing with humus before anything else becomes deficient.

No. 1416 was brought to the laboratory by Mr. E. A. White, of Lewiston, Idaho, but was taken from the Grand Coulee in Twp. 27-29 E., in the northeastern part of Douglas County. It represents a considerable area of land in this coulee which it is proposed to irrigate from springs of water coming from the walls of the coulee. The soil is a very fine clay, resembling very closely the clays of the Okanogan River Valley. The analysis shows a very well balanced condition of the essential elements of fertility. The percentages of these elements, while not high, are sufficient for a fairly permanent fertility, and if properly irrigated this soil should be very productive. The sample showed .032 per cent of black alkali, and .052 per cent of white alkali, but these amounts are not sufficient to cause injury to most crops.

ADAMS COUNTY.

The two samples from Adams Co. were secured as representing the wheat lands of the famous Ritzville district. No. 1699 was sent in by Mr. O. N. Campbell, of Hatton. It was taken from Sec 15-15-31E., and represents the virgin soil of the table land west of Hatton. The analysis shows it to be well supplied with potash and lime, but quite low in phosphoric acid and nitrogen. As these are the two elements most largely drawn upon by cereal crops, the adaptibility of this soil to long continued cropping to wheat alone seems very doubtful.

No. 1837 was sent in by Mr. D. A. Scott, of Ritzville. It represents virgin soil and was taken from the northwest quarter of Sec. 16-19-34 E. The analysis shows it to be well supplied with potash and lime, and fairly well with phosphoric acid, humus and nitrogen. It is probable that with continuous cropping with cereals alone the supply of humus and nitrogen will in time become insufficient, but for the present the soil is well supplied with plant food.

	ADAMS		WHITMAN
	No. 1699	No. 1837	No. 1888
Insoluble Silica	82 465	82.328	79.740
Hydrated "	4.268	1.500	2.220
Soluble "	0.380	0.285	0.495
Potash (K_2O)	0.450	0.411	0.506
Soda (Na_2O)	0.350	0.411	0.249
Lime (CaO)	0.618	0.591	0.508
Magnesia (MgO)	0.684	0.258	0.194
Manganese Dioxide (MnO_2)	none	none	none
Iron Oxide (Fe_2O_3)	4.205	4.403	5.196
Alumina (Al_2O_3)	4.235	5.205	4.735
Phos. Pentoxide (P_2O_5)	0.042	0.120	0.187
Sulphur Trioxide (SO_3)	0.013	0.058	0.034
Carbon Dioxide (CO_2)	none	none	none
Volatic and Organic Matter	2.505	4.249	5.190
Total	100.215	99.919	99.254
Humus	0.929	1.320	2.848
Total Nitrogen	0.043	.090	0.138
Moisture In Air-dry Soil	1.020	1.552	1.630

WHITMAN COUNTY.

No. 1888 was sent in in response to the request of the writer by Mr. S. A. Small, of Winona. It was taken from a

point a quarter of a mile east of the town of Winona and was selected as a representative sample of tne wheat lands of that part of Western Whitman County. It shows the same general characteristics as the Palouse basaltic soil and is better supplied with humus and nitrogen than was expected of a soil of so light a type.

ASOTIN COUNTY.

	GARFIELD	ASOTIN			
	No. 1134	No. 1133	No. 1420	No. 1431	No. 1432
Insoluble Silica	80.173	87.997	69.282	78.740	82.156
Hydrated "			4.212	3.968	2.618
Soluble "			0.435	0.330	0 222
Potash (K_2O)	0.567	0.320	0.434	0.426	0.391
Soda (Na_2O)	0.281	0.326	0.196	0 145	0.252
Lime (CaO	0.726	0.609	0.480	0.535	0.549
Magnesia (MgO)	0.847	0.632	0.239	0.095	0.210
Manganese Dioxide (MnO_2)	none	none	none	none	none
Iron Oxide (F_2O_3)	5.370	4 133	6.151	8.413	6.111
Alumina (Al_2O_3)	5.280	3.370	10.010	3.175	4.315
Phos. Pentoxide (P_2O_5)	0.127	0 081	0.052	0.012	0.047
Sulphur Trioxide (SO_3)	.053	0.037	0 051	none	none
Carbon Dioxide (CO_2)	none	none	none	none	none
Volatic and Organic Matter	6 355	2.526	8.723	4.062	3 322
Total	99.784	100.000	100 265	99.931	100.192
Humus	2.970	1 335	3.744	1 405	1.780
Total Nitrogen	0 164	0.046	0.185	0 064	0.032
Water in Air-dry Cells	2.416	1.040	3.468	1.378	1.404

Nos. 1133, 1431 and 1432 are samples taken under the writer's direction from different parts of the Clarkston flat. They represent three different sections of the flat. No. 1431 was taken from the upper bench, or hillside, near the high-line ditch. No. 1133 came from the main and most fertile ridge of the flat, and No. 1432 from a lower, more gravelly ridge running through the business portion of the city of Clarkston. The analyses show this sedimentary soil to be well supplied with potash and lime, but rather low in phosphoric acid and nitrogen. They are a good type of fruit soil, however. Their fertility can probably be considerably improved by sowing an occasional crop of red clover in the fall and plowing it under in the spring.

No. 1420 was sent in by Mr. J. Stucky, of Anatone. It came from the farm of Mr. C. Taplin, in Sec. 2-7-45·E., and represents the wheat-growing lands of Ten Mile Creek Valley. It is rather low in phosphoric acid, but otherwise well supplied with plant food.

GARFIELD COUNTY.

The single sample which it has been possible to obtain was sent in at the writer's request by Mr. Henry Schneckloth, of Mayview, and is said to represent the general soil of northern Garfield County. The soil is a fine black loam, of excellent physical properties. The analysis shows it to be one of the best, if not the best soil, as far as can be judged by chemical analysis, that has been found in the state. There can be no doubt of the long continued fertility of this soil.

COLUMBIA COUNTY.

No. 1135 was sent in upon request of the writer by Mr. J. W. McIntosh, of Starbuck, as a representative sample of the wheat lands of northern Columbia county. It was taken from the northeast quarter of Sec. 8-2-38 E. The analysis shows it to be very similar in composition to No. 1134, which came from the northern end of Garfield Co., with the exception that this sample is somewhat lower in humus and nitrogen. It appears, therefore, that the wheat lands lying in that part of the southeastern section of the state which lies north of the Pataha River are rich soils, well balanced in fertility, but decreasing in humus toward the west end of the district.

Nos. 1411 and 1412 were sent in by Mr. J. L. Dumas, of Huntsville. They represent the soil of the Touchet Valley. They were taken from Sec. 4-9-38 E. No. 1411 is virgin soil while No. 1412 is from adjoining land which has been under cultivation for 45 years. They show the soil to be rich and well balanced in its fertility. The effect of the long-continued cropping of No. 1412 is shown in its lower percentages of potash, phosphoric acid, organic matter and nitrogen. The proportion of the organic matter which has been converted into humus is higher because of the cultivation.

WALLA WALLA AND COLUMBIA COUNTIES

	WALLA WALLA				COLUMBIA		
	No. 1698	No. 1842	No. 1845	No. 1846	No. 1135	No. 1411	No. 1412
Insoluble Silica	83.168	79.244	77.772	78.724		68.070	68 452
Hydrated "	3.762	0.756	5.464	0.964	84.549	12 898	13.475
Soluble "	0.450	0.311	0.543	0 806		0.502	0 161
Potash (K_2O)	0.358	0.413	0.328	0.426	0 467	0.431	0 387
Soda (Na_2O)	0.326	0 259	0 238	0.315	0.233	0 374	0 331
Lime (CaO)	0.824	1.098	0 659	0.770	0.755	0.803	0 831
Magnesia (MgO)	0.306	0 140	0.104	0.140	0.793	0.437	0 509
Mangenese Dioxide (MnO_2)	none	none	none	none	none	none	none
Iron Oxide (Fe_2O_3)	4 961	4 601	4.601	7.021	5.415	4 431	4.273
Alumina (Al_2O_3)	4.820	2.315	3.925	5.620	3 595	5.510	5.925
Phos. Pentoxide (P_2O_5)	.050	0.142	0 037	none	0.110	0 162	0.152
Sulphur Trioxide (SO_3)	none	none	none	none	0.017	0 050	0.030
Carbon Dioxide (CO_2)	none	none	none	none	none	none	none
Volatic and Oaganic Matter	1.914	10.741	5.580	4.930	3.900	6.460	5.301
Total	100.939	100.020	99.251	99.766	99.814	100.128	99.831
Humus	.648	4.245	1.400	1.540	1 790	2.030	2.670
Total Nitrogen	.021	0.275	0.055	0.069	0.067	0.147	0.100
Water in Air-dry Soil	1.250	4.852	1 474	3 500	1.662	2.640	2.258

WALLA WALLA COUNTY.

No. 1698 is not a representative Walla Walla County soil. It came from a sandy bar on the south side of the Snake River near the junction of the latter with the Columbia. It was sent in by Mr. J. R. Greer, of Pasco, who requested information as to its adaptibility to certain fruits, and its probable fertilizer needs. The similarity of this soil to that of the Clarkston flat lying one hundred miles further up the river is very interesting. Practically the only difference between them is in the percentage of decayed organic matter, this being much less in the newer flat at the mouth of the river. The percentage of humus and nitrogen is, therefore, much lower in this soil. This soil needs fertilizing with some nitrogenous humus-forming material like dried blood, or tankage, which would also tend to replenish the somewhat low supply of phosphoric acid. Plowing under a green clover crop would be very beneficial treatment for such a soil. Barnyard manure, if available, would produce very excellent results on this soil.

No. 1842 was sent in by Mr. W. D. Church, of Walla Walla. It was taken from his farm in Sec. 25-7-35 E. The soil is a black clayey loam, twelve to fourteen inches deep overlaying a subsoil of yellow clay, which in turn overlays a stratum of infusorial earth. The sample represents the black earth. The analysis shows it to be very rich soil, abundantly supplied with all the essential elements of fertility.

Nos. 1845 and 1846 were sent in by Mr. J. H. Elerath, of Walla Walla. They were taken from Sec. 23-7-35 E., a part of the celebrated Blalock fruit farm. No. 1845 represents the very light volcanic ash soil which is so common throughout Walla Walla County. No. 1846 is a dark sandy loam, which has been used for several years as a garden truck soil. Both of these samples are rather low in phosphoric acid and nitrogen, but well supplied with potash and lime. The use of dried blood or tankage as a fertilizer was recommended.

BENTON AND YAKIMA COUNTIES

	BENTON						YAKIMA			
	No. 142	No. 708	No. 743	No. 745	No. 767	No. 782	No. 194	No. 545	No. 662	No. 677
Insoluble Silica	70.621	75.180	82.402	80.760	79.382	77.036	82.322	80.477	86.202	91.284
Hydrated "	10.200	8.384	3.332	7.566	6.446	7.192	5.740	3.780		
Soluble "	0.115	0.498	0 265	0.259	0.022	0.055	0.120	0.542		
Potash (K_2O)	0.427	0 329	0 312	0 288	0.304	0.415	0.212	0 144	0 293	0.125
Soda (Na_2O)	0.370	0 358	0.416	0.626	0 637	0.814	0.314	0 492	0.255	0.280
Lime (CaO)	3.451	1.570	0 944	0.987	1 721	1.250	1 631	1.770	1.078	0.648
Magnesia (MgO)	1.458	1.009	0.650	0.712	0.940	0.582	0.703	1.270	0.500	trace
Manganese Dioxide (MnO_2)	none	trace	trace	trace	trace	trace	trace	0.030	none	none
Iron Oxide (Fe_2O_3)	4 718	5.415	4.505	3.359	4 298	5 125	2.574	5.618	5 490	2.400
Alumina (Al_2O_3)	4.197	4.355	5.837	4.246	4.407	5.445	2.380	3.100	4.100	2.838
Phos. Pentoxide (P_2O_5)	0.165	0.105	0.140	trace	trace	trace	0.136	0.130	0.102	trace
Sulphur Trioxide (SO_3)	0.028	trace	0.018	none	none	none	0 025	none	trace	none
Carbon Dioxide (CO_2)	2.137	none	none	none	none	none	0.770	0 389	trace	trace
Volatile and Organic Matter	2.290	2.743	1.219	1.439	1.668	2 021	2.870	2.229	1.800	2.693
Total	100.172	99.946	100.040	100.242	99.825	99.935	99.797	99 972	99 820	100.268
Humus	trace	0.560	0 465	0.620	0.590	0.650		0 336	0.262	
Total Nitrogen	none	0.032	0.035	0.038	0 014	0.028		0.029	trace	
Water in Air-dry Soil	1.128	1.779	1.116	0.500	0.500	1 060	0.465	0.958	1.018	0.272

BENTON COUNTY.

No. 142 is a sample of the layer of white "cement" which underlays a large part of the soil of the Yakima Valley, at varying depths. It was taken by the writer from an exposure of this layer in a cellar which was being dug at Kennewick. This layer forms a hard, cement-like mortar with the gravel of the soil, but when exposed to the air it dries out and crumbles to pieces, or "slakes." It is variously considered by the citizens of that section as "cement," "alkali," "hard-pan," "lime," etc. Under the microscope it presents the appearance of finely ground glass, being composed almost wholly of minute transparent angular crystals. The results of the analysis show that it is probably a volcanic silicate, containing enough carbonate of lime and magnesia to give it slight cementing properties. A surprising amount of iron, alumina, and phosphoric acid, is present, in view of the transparent crystalline structure of the material. There is apparently nothing injurious to plant growth in this material, its worst feature being its cementing power, by which it tends to form a hard-pan impervious to water and not easily penetrable by plant roots.

No. 708 was sent in by Mr. John Murray, of Prosser. It was taken from his farm on the north side of the Yakima river, in Sec. 24-9-23 E. It represents the fine, sandy "sagebrush" soil of the Yakima Valley. Like other samples from this district, it is fairly well supplied with potash and phosphoric acid, very high in lime, and poor in humus and nitrogen.

No. 743 was sent in by Mr. Fay F. Dean, of Kennewick, who writes: "The soil was taken from Sec. 10-8-30 E., about four and one-half miles below the town of Kennewick, or near the center of the irrigated portion of the valley. It represents the soil throughout the valley, except a small portion lying on the low lands adjoining the Columbia River. The soil I send you is underlaid with a 'cement gravel' (see No. 142) at a depth ranging from eighteen inches to three feet. . . . So far as I can see, the sample I am sending you is identical with nine-tenths of the soil in the entire valley."

The result of the analysis of this sample indicates that the "Kennewick sand" is well supplied with potash, lime, and phosphoric acid, but seriously deficient in humus and nitrogen. Fortunately legumes grow luxuriantly, and the deficiency in this regard can be easily overcome by plowing under some leguminous crop.

Nos. 745, 767 and 782 represent the sandy soils of the flats, or benches, along the banks of the Columbia River, in the southern part of Benton County.

No. 745 was sent in by H. R. Mann and Co., of Spokane, and was taken from Sec. 33-6-26 E. No. 767 was sent in by Isaac Pincus and Son, of Tacoma, but came from a point in Benton County, three miles north of Umatilla, Ore. No. 782 was sent in by C. W. Corliss, of Seattle, but was taken from Sec. 8-5-27, at a locality between where Nos. 745 and 767 were obtained. It was somewhat coarser sand than the other two, containing 43.1 per cent of coarse sand and gravel, which would not pass through a 0.5mm. sieve, while the others contained only small amounts of this coarse material. All three samples were rich in lime, fairly well supplied with potash, but very seriously deficient in phosphoric acid, humus, and nitrogen. The latter might be remedied by plowing under legumes wherever irrigation is practicable, but phosphate fertilizers will be necessary in order to supply the deficiency in phosphoric acid.

YAKIMA COUNTY.

No. 194 is a sample of the white cement described above as No. 142. It was sent in by Mr. George D. Sclosser, of Sunnyside. It is similar in general character to that from lower down the valley, but contains less iron and alumina, less of the cement-forming carbonates of lime and magnesia, and correspondingly greater amounts of silica. It is more nearly pure volcanic ash.

No. 677 is another sample of the same material, taken from higher up the valley, by Professor O. L. Waller, of this Station. It is a still purer form of volcanic ash silica.

Nos. 545 and 662 are samples representing the irrigated soils of the Yakima Valley north of the river. No. 545 was sent in by Mr. Chas. Richey, of Mabton, and No. 662 by Mr. Walter N. Granger, president of the Washington Irrigation Co. at Zillah. They are very similar in character, being very rich in lime, somewhat low in potash and phosphoric acid, and very low in organic matter, humus and nitrogen.

KITTITAS COUNTY.

Nos. 722 and 723 were sent in by Mr. W. H. Rader, of Ellensburg. They were taken from his farm in Sec. 17-18-19 E., near the Yakima river. No. 722 in the surface soil, and No. 723 is the subsoil. These samples are said to represent the average soil of the lower part of the Yakima Valley in the Ellensburg district. They show the soil to be very rich in lime, and well supplied with potash, humus and nitrogen. The percentage of phosphoric acid is lower than in many Eastern Washington soils, but is ample for long continued fertility.

No. 751 is a sample of the "alkali" soil of the upper part of the Ellensburg district, handed to the writer by Mr. S. C. Boedcher, of Ellensburg. It was taken from Sec. 30-17-19. It contained 0.996 per cent of water-soluble salts, or "alkali," of which about two-thirds, or 0.636 per cent, are in the form known as "black alkali." This is much more alkali than is tolerated by any crop, and the land will have to be flooded and drained to remove this alkali before it can be successfully cropped. The sample contained over 31 per cent of carbonates of lime and magnesia. While these are not necessarily injurious substances, it is doubtful whether a soil containing so large a percentage as this will ever produce crops successfully.

KITTITAS AND KLICKITAT COUNTIES

	KITTITAS			KLICKITAT				
	No. 722	No. 723	No. 751	No. 8	No. 9	No. 190	No. 512	No. 1025
Insoluble Silica	73.360	68.648	32.880	73.456	69.070	78.626	75.792	
Hydrated "	7.181	11.232	17.384	8.184	9.398	7.258	8 472	
Soluble "	0.322	0.780	0.092	0.071	0.026	0.332	0.932	
Potash (K_2O)	0.471	0.462	0.794	0.359	0.413	0.147	0.028	0.116
Soda (Na_2O)	0.785	0.611	1.632	0.077	0.065	0.312	0.406	
Lime (CaO	1.190	2.134	14.912	0.663	0 390	0.365	0.790	0.550
Magnesia (MgO)	0.793	0.850	4 830	0.385	0 416	0.354	trace	
Manganese Dioxide (MnO_2)	trace	none	trace	none	none	trace	none	
Iron Oxide (E_2O_3)	5.580	6.324	1.033	5.045	7.242	4.945	5.857	
Alumina (Al_2O_3)	6.756	4 436	5.050	6.805	8.159	4.851	2 961	
Phos. Pentoxide (P_2O_5)	0.112	0.063	0.187	0.150	0.181	0.069	0.032	0.067
Sulphur Trioxide (SO_3)	none	trace	0.065	trace	none	0.050	0.258	
Carbon Dioxide (CO_2)	none	none	11 425	none	none	none	none	
Volatile and Organic Matter	4 311	4.517	*9.706	4.975	5.445	2.902	4.614	3.972
Total	100.864	100.057		100.170	100.805	100.211	100.152	
Humus	3.170	2.680	1.480	1.700	1.470	1.485	1.325	
Total Nitrogen	0.135	0.119	0.178	0.082	0.039	0.034	0.164	0.077
Water in Air-dry Soil	3.128	3.652	12.030	1.480	1.440	0 660	3.134	0.992

*Estimated by difference.

KLICKITAT COUNTY.

Nos. 8 and 9 were sent in by Mr. J. A. Pearson, but were taken from his ranch in Cedar Valley, Klickitat County, where cooperative experiments with this Station in growing grasses are being carried on. Mr. Pearson writes that these samples accurately represent the virgin soil of Cedar Valley. No. 8 is surface soil and No. 9 is subsoil. The soil is a heavy, back clay loam. The analyses show it to be well stocked with mineral plant food, but slightly low in humus and nitrogen. The fertility probably extends to a good depth, the subsoil being richer in potash and phosphoric acid than the surface soil and containing unusually amounts of humus and nitrogen for this type of subsoil.

No. 190 was sent in by Mr. O. F. Riebel, of Spokane, but was taken from his farm lying one mile north of Blockhouse, in Klickitat County. Mr. Riebel writes that: "This ground is all covered with a considerable growth of pine timber but is near the edge of the prairie. Some apple trees and berry bushes seem to do well, but we are told by people living in the neighborhood that the soil is sour and will not grow wheat or alfalfa—others say that a fair crop of wheat can be grown. The altitude is 1700 to 1800 feet. I would be glad to get your opinion as to what ought to be done on a soil of this kind where there is sufficient water for irrigation, and plenty of sunshine in summer." The analysis shows the soil to be rather low in all the essential element of plant food, but not likely to be "sour" Soils such as this may be fertile if thoroughly tilled, but unless very carefully handled the supply of plant food is likely to prove insufficient A complete fertilizer would likely prove very beneficial on this kind of soil. Manure would be especially valuable, as it would improve the physical condition as well as add plant food to it.

No. 512 was sent in by Mr. Albert Bertschi, of Glenwood, who describes the sample as follows: "The sample of soil represents several thousand acres of land lying in one body west of the Klickitat river, and generally known as Camas Prairie. It is light colored sandy soil from one to

four feet deep, underlaid with gravel in which there is an inexhaustible supply of water. The soil is always moist to the surface, and is always mellow, but does not produce." The analysis shows the soil to be very deficient in potash, and phosphoric acid. This is doubtless the reason for the lack of productiveness.

No. 1025 is a sample sent in by Mr. F.N.Wilde, of Lyle, who states that it comes from Sec. 13-3-12 E., and that it will not grow any of the common vegetables. It is a coarse red clay. A complete analysis was not made, but the percentages of potash, lime, phosphoric acid and nitrogen found, while low, are not so low as to account for the unproductiveness of the soil. This must be due to very poor physical condition, or to improper moisture supply in soil, or something of that kind.

SKAMANIA COUNTY.

No. 661 was sent in by Thos. Elce, of Underwood. It is a coarse red clay soil, reprsenting the soil of the foothills of the Cascade Mountains, at an elevation of 2000 feet or more. It is a fairly well balanced soil, although slightly low in nitrogen. The physical condition is such that it will need very careful tillage to get good results, but with such tillage it ought to be a quite fertile soil. No. 1102 was sent in by Mr. M. Walton, of Portland, Oregon, but was taken from his ranch in the White Salmon district in Skamania County, at a point about two miles from where No. 661 was taken. Mr. Walton, in writing in regard to the sample says that it is a very different type than No. 661. The determinations made on this sample do not show it to be strikingly different, however, except that it contains a very much better supply of nitrogen.

SKAMANIA, CLARKE AND WAHKIAKUM COUNTIES

	SKAMANIA		CLARKE			WAHKIAKUM		
	No. 661	No. 1102	No. 172	No. 330	No. 331	No. 602	No. 603	No. 604
Insoluble Silica	56.828		74.668		55.234	62.452	44.324	41.490
Hydrated Silica	10 358		8 344		11 384	9.818	20.800	6 285
Soluble Silica	0.716		0.135		0.358	0.170	0.514	0.718
Potash (K_2O)	0.385	0.318	0.166	0.066	9.178	0.354	0 610	0.134
Soda (Na_2O)	0.385		0.198		0.385	0.300	0.390	0.339
Lime (CaO)	0.540	0 452	0 486	0.200	0.862	0 552	1.542	0.145
Magnesia (MgO)	0.297		0.547		0.674	0.228	0.982	none
Manganese Dioxide (MnO_2)	none		trace		trace	none	none	none
Iron Oxide (Fe_2O_3)	7.703		6 172		5.882	7.192	10.871	10.500
Alumina (Al_2O_3)	14.084		4.555		7.942	10.396	11.549	12.763
Phosphorus Pentoxide (P_2O_5)	0 138	0.118	0.243	0.198	0.426	0.212	0.105	0.062
Sulphur Trioxide (SO_3)	none		0.043		0.084	0 107	0.0.5	0.179
Carbon Dioxide (CO_2)	none		none		trace	none	none	
Volatile and Organic matter	8.624	7.235	5.128		16.665	8.549	8.239	27.604
Total	100.058		101.185		100.074	100.330	99 981	100 220
Humus	1.730		1.510	12 515	6.770	2.950	2 890	13.100
Total Nitrogen	0.088	0.195	0.116	0.955	0 569	0.251	0 192	0.624
Moisture in Air-Dry Soil	5.460	2.480	2.038	6.050	6.866	6.900	7.133	9.190

CLARKE COUNTY.

No. 172 was sent in by Mr. Fred Edmonds, of Ridgefied. It was taken from his ranch near Ridgefield, and represents the shot clay soil so common thoughout the southwestern part of the state. It is well supplied with phosphoric acid and nitrogen, but very low in potash. The percentages of lime, while sufficient for an ordinary loam soil, is insufficient for the best results in a heavy clay of this type.

No. 330 is a sample of a very peculiar peaty soil containing some decomposed mineral matter, and many small crystals of nearly pure quartz. It was sent in by Mr. John Wood, of Amboy. The determinations made on it show that it is very deficient in potash and lime. It would require heavy applications of lime and frequent use of potash fertilizers to make this soil a fertile soil.

No. 331 is a sample of virgin soil from the parade ground of the Vancouver Barracks. It was sent in by Capt. Walden, of the U. S. Army, stationed at the post, with a request for advice as to the best treatment to secure a good growth of grass for a turf. The soil was very gravelly, containing 55 per cent. of material too coarse to pass through the 0.5mm. sieve. The analysis of the fine earth recorded in the table above shows it to be unusually rich in phosphoric acid and nitrogen, well supplied with lime, and with a fair amount of potash for a soil of this type. Heavy applications of barnyard manure, or other humus forming materials, were recommended as being the best treatment for this soil, since this would be likely to increase the availability of the plant food.

WAHKIAKUM COUNTY.

The three samples from Wahkiakum County were sent in, on request of the writer, by Mr. Henry Ahlberg, of Grays River, who described them as follows: "No. 1, (Laboratory No. 692), was taken in the brush lands to a depth of one foot, river bottom land covered with maple and crab

apple trees and elder berry and salmon berry bushes. We do not know how far to the subsoil, it appears to be the same nature for at least twenty feet, which is as far as we have ever dug. No. 2, (Laboratory No. 603), was taken from bottom land nearer to the foothills, the same kind of timber with an occasional spruce tree. No. 3, (Laboratory No. 604), was taken from a flat bench about 100 feet elevation above the bottom land. This land bears the same timber, but more spruces and an occasional hemlock. The subsoil here is a yellow clay and lies eighteen inches to three feet below the surface. We have very little of this flat upland in this county." After the samples were analyzed the following comments were sent to Mr. Ahlberg: "No. 603 should be a very rich soil. It is unusually rich in potash and lime, while the supply of organic matter and nitrogen is good, and the phosphoric acid while a little low is sufficient for all ordinary criops. No. 602 is lower in potash and lime, but still contains as much as is ordinarily present in a fertile soil, the supply of nitrogen and phosphoric acid is greater than in No. 603. No. 604 is very rich in decaying organic matter, but is very low in lime and phosphoric acid and rather low in potash. This soil is probably sour, and you will probably have difficulty in growing crops on it, particularly clovers." To this Mr. Ahlberg replied: "Your report is a great pleasure to me and a vindication of science, in the way you hit it in regard to the adaptibility of these soils to different crops respectively. . . . I know from experience which crops to select for the different soils, and you told it just right."

LEWIS, CHEHALIS AND MASON COUNTIES

	LEWIS					CHEHALIS		MASON
	No. 783	No. 784	No. 785	No. 786	No. 1772	No. 143	No. 141	No. 869
Insoluble Silica	68.992	61.580	68.434	67.572	58.066	38.356	55.046	70.144
Hydrated "	14.104	13.048	8.558	11.496	8.311	18.521	10.681	7.092
Soluble "	0.160	0.032	0.144	0.248	0.938	0.020	0.047	0.319
Potash (K_2O)	0.071	0.162	0.224	0.124	0.184	0.223	0.144	0.146
Soda (Na_2O)	0.132	0.140	0.265	0.304	0.177	0.071	0.266	0.322
Lime (CaO)	0.653	0.769	0.479	0.421	0.164	0.379	0.393	1.525
Magnesia (MgO)	0.405	0.455	0.086	0.189	0.428	0.256	0.713	0.657
Manganese Dioxide (MnO_2)	none	trace	trace	trace	none	none	none	trace
Iron Oxide (Fe_2O_3)	5.126	3.926	5.373	3.720	9.203	1.389	5.392	5.084
Alumina (Al_2O_3)	6.040	6.215	4.665	7.298	12.865	6.453	9.758	3.620
Phos. Pentoxide (P_2O_5)	0.062	0.297	0.107	0.062	0.182	0.118	0.390	0.155
Sulphur Trioxide (SO_3)	none	0.045	0.080	0.025	0.072	none	none	0.072
Carbon Dioxide (CO_2)	none	none	none	none	none	none	none	none
Volatile and Organic Matter	4.964	13.768	11.870	8.724	9.914	34.360	17.000	11.218
Total	100.709	100.437	100.301	100.238	100.504	100.149	99.833	100.199
Humus	1.340	6.710	5.580	4.015	3.743	21.210	7.860	5.200
Total Nitrogen	0.080	0.461	0.386	0.250	0.154	0.811	0.243	0.324
Moisture in Air-dry Soil	2.240	3.956	5.142	5.400	6.496	7.043	5.035	2.020

LEWIS COUNTY.

Nos. 783, 784 785, and 786 were sent in by Mr. Geo. A. Castle, of Centralia, in response to a request of the writer for representative samples of Lewis County soils. They were all taken from Sec. 30-85-3 W. They are described by Mr. Castle as follows: No. 1 (Laboratory No. 783) Hill soil, burned, cleared, plowed, and sowed to red clover four years ago, not plowed since. No. 2 (Laboratory No. 784) Hill soil, similar to No. 1; has been manured and in garden for several years. No. 3 (Laboratory No. 785) Bottom land soil, cropped for twenty years, never manured much No. 4 (Laboratory No. 786) Bottom land soil cleared in 1870, and farmed ever since. Very little manure was ever used on this field. The large variations in the results of the analyses of these soils are difficult to account for. It seems impossible that manuring alone could account for the large increase in all the essential elements of fertility in No. 784 as compared with No. 783. Or that the longer continued cropping alone is responsible for the large decrease in these elements in No. 786 as compared with No. 785. If these differences of treatment are the only causes for these striking differences, then the advantages of proper handling of these clayey soils are most apparent.

No. 1772 was sent in by Mr. Geo. Campbell, of Dryad, who writes: "The land from which this sample comes has been cleared for four or five years. It has been cultivated for at least three years. Last year it was in wheat and yielded a small crop except where there had been patches of ashes. It was originally covered with a heavy growth of fir. The land is on the first bench above the Chehalis river, perhaps 30 or 40 feet above the valley." The analysis shows the soil to be fairly well supplied with phosphoric acid and nitrogen, but low in potash and very low in lime. A clay soil of this type needs plenty of lime and the lack of fertility is doubtless due to a lack of lime and of available potash.

CHEHALIS COUNTY.

The two samples of soil from Chehalis County were sent in by Mr. James Moore, of Satsop. No. 143 represents the peaty soil of an old reclaimed swamp, and No. 144 the upland or bench land of the Chehalis Valley. These samples are very high in organic matter, and sour from an excess of organic acids. A quantitative estimation showed that it

would take at least eight tons per acre of dry lime to completely neutralize the acidity of soil No. 143. At the suggestion of the writer Mr. Moore is now making some experiments to determine just how much lime he can afford to use on this soil. These soils are rather low in potash, also, but well supplied with nitrogen and phosphoric acid. It is probable that heavy applications of lime will be all that will be necessary to bring them to a high state of fertility.

MASON COUNTY.

Only one sample has ever been received from Mason County. It was sent in by Mr. J.M. Sweetland, of Union, who states that the soil is bottom land, that this sample was taken from Sec. 7-22-3 W., and represents all the tillable land in that part of the county; that this land has been under cultivation for 45 years and still yields good crops. The analysis shows that the sample is somewhat low in potash but otherwise well supplied with plant food.

KING COUNTY.

Nos. 159 and 160 were sent in by Mr. B. W. Alexander, of Vashon, at the request of the Vashon Island Horticultural Association, in order to learn if possible why one soil is better adapted to the production of the Clarks Seedling strawberry than the other. No. 159 was taken from the northwest quarter of the northwest quarter of Sec. 29-23-3E. It grows this variety of berries most satisfactorily. It was formerly covered with fir timber. After clearing it was seeded to red clover and used as a pasture for ten years. Commercial fertilizers were applied each year—usually tankage, at the rate of half a ton per acre. This soil contained 37.1 per cent. gravel, etc., and 62.9 per cent fine earth, and was in fairly good physical condition. No. 160 came from the northeast quarter of the northeast quarter of Sec. 6-22-3 E. This land does not produce Clarke's Seedling berries, although other varieties do well. The land was originally covered with fir and alder timber. It has been cropped three years to potatoes, peas and strawberries, respectively. It has never been fertilized. The soil contiains 44.8 per cent gravel, and 55.2 per cent fine earth, and is in rather poor physical condition, containing many hard lumps. The analyses show that No. 160 is much better supplied with total plant food than No. 159. The difference in physical condition, and probably also in the availability of the plant food caused by the clover pasturage and the use of fertilizers doubtless accounts for

the better growth of berries on the soil which is poorer in total plant food.

Nos. 499, 500 and 744 were sent in by Mr. Marion Edwards, of Seattle. The first two were taken from land owned by him, at Brighton Beach, in Sec. 26-24-3 E. This is an old fern prairie region lying on the west shore of Lake Washington. No. 499 came from a spot which had been for some time a violet bed which had been fertilized with manure for several years. No. 500 was taken from a spot about one hundred feet away, which had never been fertilized or cultivated. No. 744 came from a farm about a quarter of a mile south of this locality from land owned by Mr. Albert Koch, which is of the same general type as the other two samples, but is unproductive. Hay, oats, and potatoes are alike failures on this land. The results of the analyses fail to show any reason for this lack of fertility. No. 744 is richer in potash and lime, than the other two soils, is abundantly supplied with nitrogen and humus. The phosphoric acid content is lower than in the other two samples, but is well above the limit that is usually considered ample for farm crops. It may perhaps be that conditions in this soil are such that the phosphoric acid is not in available form. No. 499 shows quite a marked effect of the fertilization with manure, in its increased humus, nitrogen and phosphoric acid. The most surprising thing about these soils is their high percentage of lime, a very unusual occurrence in soils from that section of the state.

SAN JUAN COUNTY.

No. 394 was sent in by Mr. G. E. Goodwin, of Bellingham, but was taken from his farm on Orcas Island. It is very coarse soil, containing 59.1 coarse sand and gravel, and only 40.9 per cent earth fine enough to be available for plant food purposes. The fine earth is rich in lime and phosphoric acid, but rather poorly supplied with potash and nitrogen.

Nos. 870 and 871 were taken from land on the island lying in Sec. 28-37-2 W., at an elevation about 175 feet above sea level. No. 870 represents alder bottom land and No. 871 fir upland. Both are now in prune orchard, which does not bear satisfactory crops of fruit. No. 870 contained 21. per cent and No. 871 35.8 per cent of gravel, coarse sand, etc. The percentage of potash in these soils is low, otherwise they are well supplied with plant food, except possibly the phosphoric acid in No. 871. It is probable that the failure of the trees to fruit well is due to some climatic condition rather than the lack of fertility, but it is possible that fertilizing with potash salts might improve the yield of fruit.

KING AND SAN JUAN COUNTIES

	SAN JUAN			KING				
	No. 394	No. 870	No. 871	No. 159	No. 160	No. 499	No. 500	No. 744
Insoluble Silica	74.080	64.636	77.327	76.652	72.297	61.150	50.884	67.772
Hydrated "	9.548	7.318	5.514	8.572	8.646	6.902	18.344	4.452
Soluble "	0.107	0.180	0.247	0.348	0 062	0.052	0.264	0 087
Potash (K_2O)	0.151	0.180	0.162	0.126	0.157	0 125	0.153	0.192
Soda (Na_2O)	0.303	0.233	0.328	0 106	0.167	0.207	0 330	0.500
Lime (CaO)	0.873	1.060	1 031	0.615	0.693	1.089	1.089	1.321
Magnesia (MgO)	0.906	0.630	0.481	0 807	0 518	0.398	0.658	0.602
Manganese Dioxide (MnO_2)	none	trace	trace	none	none	trace	none	trace
Iron Oxide (Fe_2O_3)	4 167	5.167	4.095	3.064	3.023	3.472	5 373	2.687
Alumina (Al_2O_3)	5.883	7.028	5 653	4 852	7 634	5.662	10.327	8.067
Phos. Pentoxide (P_2O_5)	0 300	0.125	0 087	0.044	0.073	0 266	0.190	0.124
Sulphur Trioxide (SO_3)	trace	0.041	0.072	none	none	0.018	0.062	0.118
Carbon Dioxide (CO_2)	none	none	none	none	none	none	none	none
Vol. & Organic Matter	3.560	13.879	5.020	4 467	6.975	18 168	12.445	14.366
Total	99.932	100.411	100.047	99.653	100.275	100.539	100.119	100.288
Humus	1.680	8.410	3 750	1 870	3 100	11.170	5.820	9.080
Total Nitrogen	0.089	0.520	0.172	0.077	0.154	0.547	0.415	0.505
Water in Air-dry Soil	1.819	4.232	3 480	1.941	3.950	5.482	5 142	3.744

Summary of the Soil Survey of the State

The soil analyses recorded in this bulletin practically complete the soil survey of the State, which was commenced by the Department of Chemistry of this Station fourteen years ago. In the course of this survey one hundred and eighty-eight samples of soil have been analyzed, coming, as is shown below, from every county in the state except one. We believe that these samples include representatives of every type of soil which is found in the state, and that we have now on our records information as to the composition of every type of soil with which our farmers will have to deal. While the results of a chemical analysis do not show many things which farmers would like to know about their soils they do afford certain valuable information concerning the general character of the different types of soil and often furnish indications of probable fertilizer needs of the soil and lead to suggestions as to improvements in its crop producing power. Such general conclusions as may be safely drawn from the results of this soil survey are presented in this summary, together with a few suggestions as to soil treatment which it is believed may be profitably applied in some sections of the state. More complete and more detailed information concerning the maintenance and improvement of soil fertility will be found in a bulletin on this subject which is now in preparation and will be issued in the near future.

The one hundred eighty-eight soil samples which have been analyzed in connection with this survey were distributed as follows:

EASTERN WASHINGTON

Adams	County,	4	samples
Asotin	"	4	"
Benton	"	5	"
Chelan	"	4	"
Columbia	"	3	"
Douglas	"	6	"
Ferry	"	3	"
Franklin	"	2	"
Garfield	"	1	"
Kittitas	"	3	"
Klickitat	"	5	"
Lincoln	"	4	"
Okanogan	"	7	"
Spokane	"	13	"
Stevens	"	10	"
WallaWalla	"	8	"
Whitman	"	6	"
Yakima	"	11	"
	Total	99	"

WESTERN WASHINGTON

Chehalis	County,	2	samples
Clallam	"	2	"
Clarke	"	8	"
Cowlitz	"	none	
Island	"	2	"
Jefferson	"	3	"
King	"	11	"
Kitsap	"	5	"
Lewis	"	5	"
Mason	"	1	"
Pacific	"	2	"
Pierce	"	9	"
San Juan	"	6	"
Skagit	"	12	"
Skamania	"	2	"
Snohomish	"	5	"
Thurston	"	4	"
Wahkiakum	"	3	"
Whatcom	"	7	"
	Total	89	"

In some of the counties the number of samples is not so large as might be desired. We have not been able to send out soil survey parties from the Station, but have had to depend upon interested persons in the several localities to secure the samples for us. The number of samples from a given section depends, therefore, partly upon the number of soil types in that section and partly upon the amount of cooperation from persons in that section which we could secure. The distribution of these samples throughout the state is shown in the accompanying diagram (Fig. 1). The apparent absence of representative samples from certain large areas in the diagram is due to the fact that these areas are mountainous and heavily timbered, and contain little or no agricultural lands. In this connection the illustration of the topography of the state as shown by the relief map of the state made by Professor Shedd of the State College, a photograph of which is reproduced in Figure 2, is of interest. This makes plainer also the conditions and limitations of the agricultural soils of the state as described in the summarized statement below.

For the purposes of discussion of the character of the soil the state may be roughly divided into several districts, as follows: The Puget Sound district, including all the part of the state west of the Cascade Mountains which is drained into Puget Sound; the South-West section, which includes all the rest of the state lying west of the Cascades, and is drained either directly into the Pacific Ocean or into the Columbia River; the central, chiefly irrigated, section, which includes Klickitat, Benton, Yakima, and Kittitas Counties; the Okanogan section, including Chelan, Okanogan, Ferry, Stevens, and the north half of Spokane Counties; the Palouse section, which comprises Whitman County and the South half of Spokane County; the Big Bend section, comprising Douglas, Lincoln, Adams, and Franklin Counties; and the South-East section, including all that part of the state lying south of the Snake River.

The Puget Sound District.

The agricultural lands of this district lie in the flats bordering upon Puget Sound and in the valleys of the rivers which flow into it. The remaining lands of this section are mountainous and heavily timbered, and not, as yet, to be considered as agricultural soils. The flats are level lands which lie very low, only a few feet above sea-level and in some cases, even below the level of high tide. These latter are protected from the salt water of the ocean by dykes which have been built for that purpose. Such lands form the celebrated "reclaimed tide flats." Both these reclaimed flats and the other flats lying at a higher level are made up of sand brought in by the tides, mixed with alluvial material washed down from the higher lands. They are, therefore, usually of very fine physical condition and apt to be very fertile. The higher flats are particularly rich in decaying organic matter, or humus, and are apt on that account to be "sour" because of the excess of organic acids which they contain. In some localities certain small areas of soils are found which show very peculiar composition, probably because of old lake beds, old swamps, or other local features. Concerning these it is obviously impossible to make general statements.

The river valley lands of this section may be divided into three types; the low land lying in the bottoms of the valleys, commonly called "alder-bottom land"; the upper benches lying at some distance back from the rivers and a higher level and sloping up toward the hillsides, usually spoken of as "red-fir upland soils"; and the timbered ridges, a few of which have been cleared and are being cultivated. The soil of the ridges and hills of this section is, for the most part, a stiff, heavy, reddish clay,

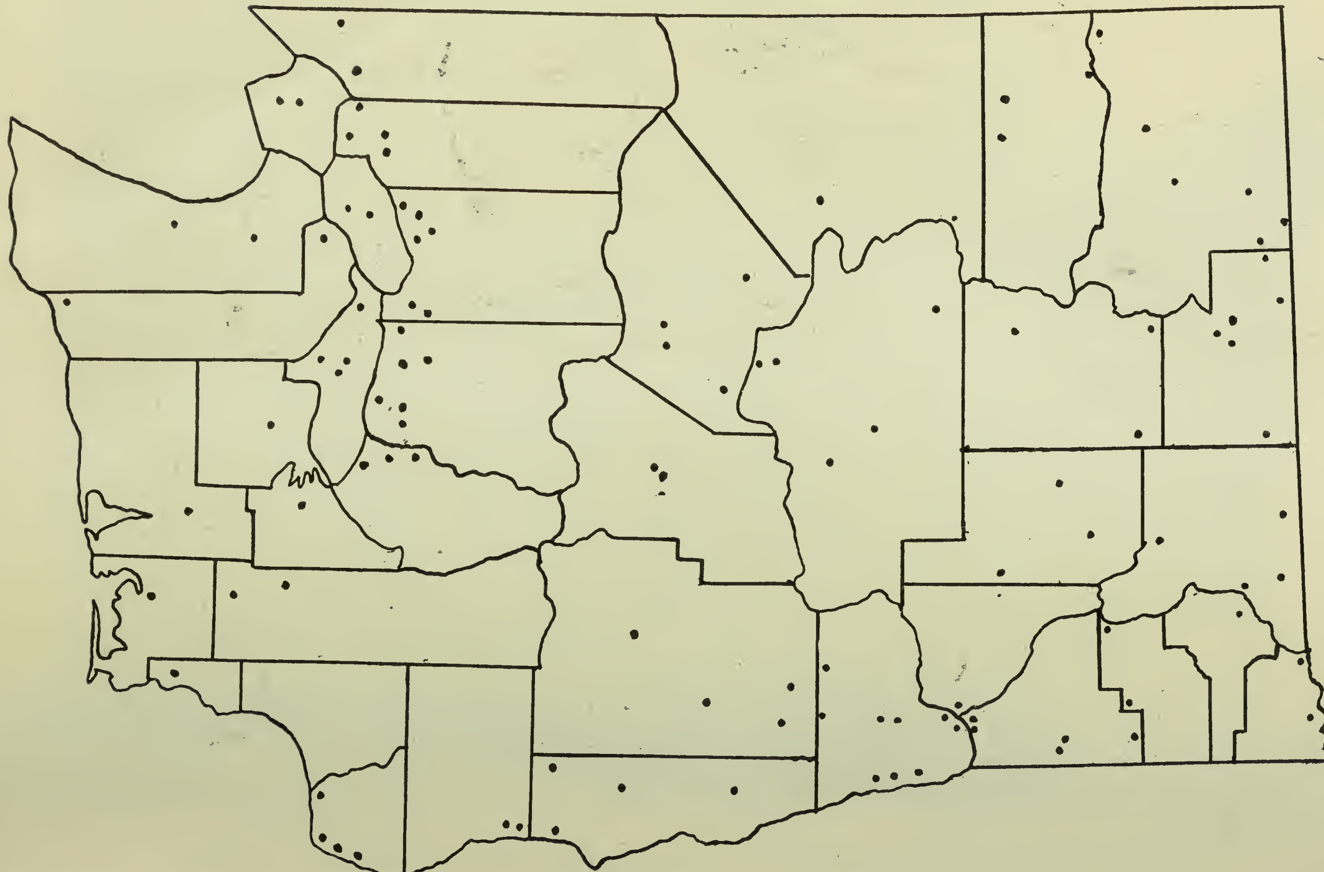

FIGURE 1—Showing distribution of samples analyzed in the soil survey

FIGURE 2—Map showing contour of the state. Agricultural lands are in the valleys and table lands.

often quite gravelly and frequently containing considerable amounts of poorly decayed forest residues. Such soils are usually in poor physical condition, difficult to work, and not very fertile. The chief plant residues which they contain are the cones, needles, etc., of fir, and pine trees, which decay very slowly and form very poor humus. Very little can be done in the way of green manuring, or plowing under of clover crops, and commercial fertilizers are about the only remedy for the infertile condition. This poor quality of the soils of the ridges makes it appear that no great advantage can be gained by further clearing and plowing up of these timbered areas. The red-fir uplands, or second bench lands, appear to have been formed largely by the broken rock, gravel, and other debris which has come down from the hillsides. In the natural state they are usually heavily timbered. When cleared of timber they become covered with immense growths of ferns. When plowed, they are usually very gravelly, light in color, and apt to be not very fertile, except where the land has been burned over and a considerable quantity of ashes left. They usually contain only limited amounts of humus, because of the poverty of this in the higher lands from which they came. Clovers of various kinds often make very good growth on these soils and their fertility can usually be very materially improved by frequent turning under of some clover crop. The alder-bottom lands usually consist of a layer of rich black soil of varying thickness, overlaying a sub-soil consisting of very gravelly clay mixed with large stones. These soils are usually well-watered and in ordinary seasons yield immense crops, particularly of hay and roots. They have very poor water-holding capacity, however, and in seasons of drought dry out very rapidly and the crops burn badly. These bottom lands are usually heavily charged with decaying vegetable matter, sometimes being very peaty in character. They are, therefore, usually well stocked with nitrogen. As a rule they contain more potash and less phosphoric acid than the upland soils.

From the standpoint of chemical composition, the most striking characteristic of the soils of this region is the very low percentage of lime which they contain. This is doubtless the result of the heavy rainfall and excessive leaching out of the lime in these soils. It results in a very poor physical condition of the clay upland soils, making them stiff and inclined to bake hard when dry, and in frequent cases of acidity or "sourness" of the lower land soils. Except in those localities near the lime rock, which is found in one of the two localities in this district, there are very few soils which would not be likely to be materially improved in their physical condition or their fertility, or both, by a liberal application of lime. The potash content of the soils of this region is likewise very low, particularly in the uplands. This is true throughout that part of the state lying west of the Cascade Mountains and is due to the long-continued leaching of the soil by the heavy rain-fall. Potash fertilizers are now in extensive use in these districts, and will probably be increasingly necessary. The beneficial effect of wood-ashes which is so frequently noticed in this part of the state is doubtless due to the lime and potash which they supply. Phosphoric acid is usually present in sufficient quantities in the upland soils, but likely to be deficient in the lower lands. Nitrogen is present in abundance in the bottom land soils but is often deficient in the upper gravelly or clayey soils, particularly if they have grown large forests of fir and pine.

The Southwestern Section.

This district is almost wholly made up of broken or rolling hills, with the exception of the extreme northern end of it, where are found several open level prairies. The agricultural lands comprise these open prairies and the valleys of the rivers. The river valleys are, for the most part, somewhat

broader and the hills surrounding them less abrupt than in the Puget Sound district. The soils of these valleys are wholly different in type from those of the Puget Sound district also, since the latter are produced from glacial drift brought in from other localities, while the soils of this district were produced almost entirely by the decomposition of the rocks of the hills of the district itself.

The open prairies of this section consist of immense level deposits of coarse sand and gravel formed by the melting of the glaciers which at one time flowed through the great Puget Sound depression. These deposits are so very gravelly as to possess only very slight agricultural value, but bordering upon them are considerable areas of tillable land, and in several places in them there are depressions of greater or less extent forming more or less marshy areas which when properly drained become very rich farming lands. The parts of the gravelly prairies which are cultivated are usually inclined to be deficient in all the essential elements of plant food, with the possible exception of phosphoric acid. The marshy lands are almost invariably "sour" because of excess of decaying organic matter and lack of lime.

The river valleys show a great variety of types of soil. In some, depressed areas which were formerly old river beds and later swamps filled with vegetable debris are occasionally found, which result in very peaty soils—some even containing so high a proportion of vegetable matter as to be practically worthless for crop production. A very common type of river bottom soil is a heavy, black clay, commonly known as "beaver-dam" bottom lands. These are alluvial drifts brought down from up the streams by the current at times of high water. They contain little or no sand but are essentially fine clay mixed with comparatively large quantities of well decayed organic matter. They contain very large stores of nitrogen and are usually fairly well stocked with phosphoric acid, but are not very liberally supplied with potash, and frequently are "sour," the supply of lime being insufficient to neutralize the excess of organic acids present. These are ordinarily very productive soils, but have often been found to yield very profitable returns to fertilizing with potash and lime. Occasionally sandy bars deposited at some abrupt turn of a river are found, but these are not of sufficient extentto be considered of much general importance.

The higher bench lands of this district are essentially clayey in character, but exhibit a great many different types. Perhaps the most common is the "shot-clay," so called because of its tendency to break into small hard pellets when dry. This type is usually a strong soil, containing ordinarily a fairly good supply of phosphoric acid and nitrogen, but apt to be somewhat deficient in potash. The percentage of lime is rarely very high, but seems in most cases to be sufficient for immediate needs, as several experiments in liming this type of soil have not given any strikingly beneficial results. It seems probable that the physical condition, and the fertility also, of this shot-clay would be improved by green manuring. Another common type of bench land soil of this section is a rather heavy, yellowish to brownish, clay loam, found chiefly in the wide, open valleys. This is nearly always fairly well supplied with all the essential elements of plant food, but frequently does not contain as high a percentage of lime as is desirable in clay soils, hence, is more or less heavy and difficult to work when wet and inclined to bake when dry. This type is especially susceptible to improvement by plowing under a green clover crop. Vetches are admirably adapted for this purpose.

The hill lands of this district consist chiefly of a reddish, or yellowish, clay, containing as a rule, very little coarse sand or gravel. They are richer in phosphoric acid than any other type of soil west of the Cascade Moun-

tains in this state. They usually contain a rather poor supply of humus and nitrogen and are not very well stocked with potash. With the exception of their phosphoric acid content they are the poorest soils of this section, and will probably require the most extensive use of fertilizers. Barnyard manure is a particularly valuable fertilizer for this type of soil, since it supplies the humus which is needed both as a means of rendering available the plant food and to improve the physical condition of the soil.

A very striking characteristic of all the soils of this district is the very high percentage of iron oxide and alumina which they contain, amounting oftentimes to twenty per cent or more of the dry soil. This indicates that the soils are almost wholly clay or decomposed rock of the feldspar or granite type, and contains very little sand or decomposed quartz. Such soils are likely to prove of high and very permanent fertility if properly tilled,but are generally very difficult to cultivate. They require large amounts of humus to keep the fertility in available form, to make the clay able to absorb and hold moisture, and to prevent puddling when wet and baking when dry. The best treatment for such soils is one which will frequently add to the soil some organic matter, either in the form of barnyard manure, or a green leguminous crop plowed under. Temporary stimulation and improvement in physical condition may often be secured by heavy liming of these soils.

The Central Section.

The rain-fall is lower than in any other part of the state and farming is carried on almost entirely by irrigation. Some of the uplands in the southern part and the lands lying toward the foothills of the Cascade Mountains receive sufficient rainfall to permit cultivation without irrigation. All these uplands are well supplied with potash and lime, except those lying well up on the sides of the mountains at an elevation of 3000 feet or more. Above this line the soils are of the same general type as the hill soils of the Southwest section on the other side of the Cascades. The lower foot hill soils of this section are rich in all the essential elements of plant food, and appear to be of great permanent fertility. As the distance from the mountains increases, however, the supply of humus, nitrogen, and phosphoric acid decreases, and the proportion of infertile sand increases until at the extreme eastern part of the district the amount of humus and nitrogen is less than that considered by soil experts as necessary for plant growth. Conditions are very favorable for the plant food to be largely in available form, however, and whenever sufficient rainfall can be had crops are successfully grown. Soils of this class cannot exhibit any great permanence of fertility, however, unless steps are taken to increase their humus content.

The valley, or irrigated, soils of this section consist chiefly of a layer of sandy soil, of the so-called "sage-brush" type, overlaying a sub-soil of coarse gravel through which run layers of "hard-pan" or of a white volcanic ash locally known as "cement." This soil is obviously sedimentary in its character and was undoubtedly deposited in the bed of an old lake which once covered this region. Chemically, this soil is very rich in lime, but much poorer in potash and nitrogen than other soils of Eastern Washington. The abundance of lime and other conditions are favorable for rendering the plant food easily available, and when watered the soils show very great fertility. This fertility cannot be permanently maintained, however, without the addition of some humus-forming material. Fortunately, legumes can be grown with the greatest ease, and when plowed under will supply this lack. Potash fertilizers will probably be required in the not far distant future, particularly for fruit and vegetable crops. The occurrence of alkali in the soils of this region and treatment for it have been discussed in Bulletin No. 49 of this Station.

The Okanogan District.

This district comprises all that part of the state lying north of the Columbia River, from Lake Chelan and the Cascade Mountains to the Idaho line. The agricultural resources of this part of the state have not as yet been fully developed and many fertile valleys which will in time become profitable agricultural lands are as yet uninhabited wilds. The comparative newness of the agricultural development of this district has made it impossible to secure a very complete survey of its soils. Some general conclusions may be drawn, however. The topography of the country is that of a very hilly, rolling tableland, quite similar in many respects to that in the Southwestern section of the state. The rocks of the hills from which the soils are derived are also largely granitic in type, making the prevailing soil types clayey ones. The clays of this section differ from those of the Southwest section, however, in that they must have not been subjected to so heavy rainfall and leaching as those under the West-side conditions and are, therefore, usually richer in lime and potash. This gives them a much more friable character, and greater fertility, because of better availibility of the plant food which they contain. Peaty meadows of the same general type as found west of the Cascades are found in many places in this section. These are, however, practically the only soils of this section which are likely to require liming.

In the western part of the district the river valley soils are usually made up of large proportions of a very friable clay mixed with considerable fine sand, making a combination very easily cultivated and of high fertility. In the eastern part development has been somewhat more advanced, and farms have been extended up to some of the upper benches and higher hillsides. These are usually found to be somewhat less fertile than the bottom lands, being lower in humus and more difficult to work. The valleys of Southern Stevens County show a heavy clay soil, inclined to be deficient in nitrogen and humus, but well supplied with lime and potash. Occasional very calcareous (that is, containing high percentages of carbonate of lime) soils are found. In fact, a high lime content may be said to be the most striking characteristic of the soils of this district. Soils of this type are almost universally considered as having high crop-producing capacity, and it would appear that further development of this section will add much to the agricultural resources of the state.

The Palouse District.

The prevailing, and practically the only, type of soil in this district is a decomposed basalt, a fine loam of high fertility, easy tillage and great water-holding capacity. The land is rolling, and the soil on the south-hill slopes is for the most part shallow and inclined to be clayey, but elsewhere deep and rich. The proportion of clay is greatest towards the hill tops. Humus increases as we go down the slopes, and is highest in the valleys, forming a rich black loam with occasional patches of "adobe."

This Palouse type of soil is very rich in potash and phosphoric acid, and fairly well supplied with lime. The supply of humus and nitrogen is only moderate, and in the western part of the district is quite low. The present system of almost exclusive cropping to cereals is making large demands upon the stock of humus, which will have to be counteracted by some system of restoration of humus to the soil in the not far distant future. All other elements of plant food are present in practically inexhaustible supply, and with proper attention to the humus needs this soil will doubtless maintain its reputation for high fertility indefinitely.

The Big Bend Section.

In its general topography this section is a level or slightly rolling plateau, cut by numerous river beds with almost perpendicular walls of basalt rock, known as coulees. Some of these coulees contain flowing streams, others have streams in which running water is found during the winter and early spring months, and still others are dry beds of old rivers, which have now ceased to flow because of decreased rain-fall or because of a change in their course to some other line of flow. Many of these coulees are wide enough so that a certain amount of tillable land is found in them. This soil is moist, usually well supplied with humus and, particularly in the northwestern part, shows a composition very similar to that of the river valleys of the western part of the Okanogan section. Most of the agricultural lands of this section are found upon the rolling table-land, however. In their general type, the upland soils or so-called wheat-lands of this section are a decomposed basalt, very similar to that of the Palouse section, but carrying less humus in direct proportion as the average annual rainfall of the locality becomes less.

In the southwestern part of the Big Bend district there is a very large area where the annual rain-fall is so slight that only sage-brush and small patches of the hardier bunch grasses can grow. Here the soils are very sandy and contain only slight amounts of decayed organic matter. They are well supplied with the mineral constituents of plant food, however, and if supplied with sufficient water will produce abundant crops. With a proper supply of water to grow leguminous crops their humus content could be very easily built up, hence if any feasible way of watering these soils can be devised they may become very valuable agricultural lands. An abundance of water will be necessary at first, however, since the soils are so sandy and contain so little humus that they have very little water-holding capacity.

In the regions of sufficient rain-fall the soils of this district are well supplied with the mineral elements of plant food, lime especially being present in large supply, particularly in the northwestern part where a surplus of carbonate of lime is often found giving a tendency to form hardpan. With a sufficient supply of humus, therefore, these soils will possess a very high and very permanent fertility. Unfortunately, the natural supply of humus is low, and in many localities the soils are already showing a strong tendency to run together when damp and form crusts when dry, a sure evidence of deficiency in humus. With a system of soil cultivation which will introduce some humus-forming materials at rather frequent intervals, these soils promise very high fertility for a long time to come, but without such treatment very diminished crops will probably result in the not far distant future.

The Southeastern Section.

The agricultural lands of this section are of two general types, the light volcanic ash soil derived from the decomposition of the rocks of the extreme edge of the basaltic overflow of the state, and a heavier loam bordering on the foothills of the Blue Mountains and resulting from the decomposition of the rocks of this range of mountains. The line of demarcation between these two types is very irregular because of the irregularities in topography which limited the edge of the lava overflow, but is fairly sharp and well defined. In the valleys of the streams the nature of the soil is, of course, much changed from these original types of sedimentation, etc., but the upland soils fall very clearly into one of the other of these types. The Blne Mountain loam is a soil rich in all the essential elements of fertility, especially in

potash. The percentage of humus and nitrogen is high near the foothills of the mountains, but decreases as the distance from them increases and the resulting annual rainfall decreases. The soils of the north and west slopes of these mountains are probably the richest distinct type to be found in this state. On the eastern slope in the extreme southeast part of the state the soils contain less humus and are more clayey in their nature. They are very much lower in phosphoric acid also, their most characteristic feature as far as chemical composition is concerned being a probable deficiency in this constituent.

The light volcanic ash soils of the northern and western parts of this section resemble those of the western part of the Palouse and Big Bend sections. Physically, they are very finely divided, forming an almort impalpable dust when dry, but possessed of very great water-holding power when wet. Chemically, they are very abundantly aupplied with potash, lime, and phosphoric acid, but very low in humus and nitrogen. What was said in regard to the soils of the Big Bend section applies equally as well to the soils of this part of the Southeastern section.

General Conclusions.

Even the most casual glance at the results of this soil survey will show the extreme variations in the kinds of soil which are found in this state. Practically every type known to soil students is represented somewhere in this state. We have every variation from almost pure sand to pure clay on the one hand and to pure peat on the other. In other localities special types, such as marls, glacial drift of several kinds, etc., etc., are found. These variations in type are accompanied by almost the widest conceivable variations in chemical composition. The extreme variations in the percentages of the several constituents which have been found in the samples of soils which we have analyzed are shown in the following statement:

Insoluble silica	3.014 — 90.716 per cent.
Hydrated silica	0 157 — 18.524 per cent.
Soluble silica	0.002 — 0.938 per cent.
Potash	0.000 — 0.829 per cent.
Soda	0.027 — 1.632 per cent.
Lime	0.005 — 36.009 per cent.
Magnesia	0.000 — 4.830 per cent.
Iron Oxide	0.181 — 16.368 per cent.
Alumina	0.148 — 14.898 per cent.
Phos. Pentoxide	trace — 0.409 per cent.
Sulphur Trioxide	0.000 — 0.694 per cent.
Carbon Dioxide	0.000 — 28.998 per cent.
Humus	0.084 — 51.000 per cent.
Nitrogen	trace — 2.660 per cent.

In addition to the discussion of the soils in the different sections of the state given above the following general statements made in Bulletin No. 55 may profitably be repeated:

"The soils of the western, central and eastern portions of the state show marked differences in their percentages of potash and lime. The potash content is generally greatest in the eastern part and least in the western, while in the central portion the amount is intermediate. The lime content is greatest in the central part, where the minimum amount of rain falls. It is least in the western part, especially in those portions where the rainfall is forty inches or more. An intermediate amount is found in that portion where the rainfall varies from eighteen to thirty inches.

"In many of the samples from Eastern Washington the amount of soda exceeds that of potash. This is unusual (except in alkali soils) and is doubtless due to the basaltic origin of the soil, and to the climatic conditions attending the soil-forming period. In general, the wide variations in composition between the virgin soils in different sections of the state are due to (1) origin; (2) climatic conditions both present and past; (3) past vegetation.

"Fertilizers containing lime and potash will be found most generally beneficial to soils west of the Cascade Mountains.

"In the irrigated regions humus-forming materials with added potash would in most cases best meet the soil needs.

"When fertilization is required in Eastern Washington it is probable that humus-forming material and, in some cases, lime, would give maximum benefit at the minimum cost."

THE STATE COLLEGE OF WASHINGTON

Agricultural Experiment Station

PULLMAN, WASHINGTON

DEPARTMENT OF ZOOLOGY

The Codling Moth in 1907

By A. L. MELANDER
Assisted by R. E. TRUMBLE

Bulletin No. 86

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The Codling Moth in 1907 *

By A. L. MELANDER
Assisted by R. E. TRUMBLE

For a number of years the Washington State Experiment Station has been studying the codling moth. In the course of the investigation arsenate of lead was found to give best satisfaction as a spray, and the usual number of sprayings necessary was found to be three or four. Experiments were carried on in the Yakima Valley, the Spokane country, and on the Snake River bluffs. In 1907 the campaign was extended to Walla Walla and Wenatchee. Thus we have now carried on spraying demonstrations in practically all the commercial orchard localities of the state.

HISTORICAL.

The main purpose of this year's work was to demonstrate how easily the codling moth could be kept in check by proper spraying methods. At the same time tests were made of the value of the dust spray and of the newer brands of arsenate of lead. For the demonstration several badly infested orchards were taken in charge and were sprayed entirely by us. Gasolene power sprayers were used in all liquid spraying.

OBJECTS IN 1907.

In general spraying at Walla Walla is carried on in a desultory way. Many of the growers are using methods of a decade ago with only partial success, and have become disgusted with the codling moth outlook. In the warm Walla Walla valley the codling moth breeds prolificly. It seems certain from this year's observations that the growers there have three broods to contend with. Many orchards are abandoned or are being cut down for fire wood.

WALLA WALLA CONDITIONS.

The orchard of E. Lennon in the city of Walla Walla was

* Contribution from Zoology Laboratory of the State College of Washington

selected as an extreme example of an abandoned orchard.

LENNONS' ORCHARD. Originally this place produced 20,000 boxes of apples a year, but because of the codling moth and the San Jose scale the major part of the orchard had been cut down and disposed of as fire wood in order to use the ground for growing wheat. At the time of our visit but 150 trees remained and of these fifty had been sold when the orchard was divided into town lots.

The trees selected for spraying are among the oldest in the valley, some being twenty, others nearly thirty years of age. As they have not been pruned for years, they have grown far out of reach of the spray nozzle. The ground is uncultivated and this year was sown to wheat, but close to the trees the wild sweet clover as well as alfalfa and white clover of former plantings were growing rank. In the midst of the orchard is a large shed wherein had been piled about one thousand boxes of wormy apples the winter previous. During the summer the fruit was not thinned; the close clusters of apples were so numerous as to bend the untrimmed branches to the ground. All in all a more severe test of codling moth spraying could not be imagined.

As the trees were thickly incrusted with scale a preliminary step was to have the orchard sprayed with sulphur-lime. The efficiency of this treatment was apparent in the absolute extinction of this pest.

Four sprayings of arsenate of lead (one pound to forty gallons) were given for the codling moth with the most gratifying results, as the following table shows. The dates of the applications were, May 9, June 28, July 31 and August 31.

TABLE I.

Variety	How Sprayed	Picked		Windfalls		Per Ct. Good
		Clean	Wormy	Clean	Wormy	
1. Arkansas Black	Liquid, 1:40	700	8	....	....	98.9
2. Rome Beauty	" "	1437	10	136	4	99.2
3. Arkansas Black	Dust	232	106	250	500	60
4. Rome Beauty	Dust	236	99	19	100	60
5. Winesap	Not Sprayed	17	250	1	250	3.4

Partial counts, including apples from all levels of the tree, were made of two Arkansas Black and three Rome Beauty trees taken at random. These counts represent a just average of the orchard, and as they show 99 per cent. of the fruit free from worms, they afford a striking contrast to the three per cent. clean of the unsprayed trees.

A dozen trees were sprayed with a dust sprayer to test the efficiency of this method as compared with liquid spraying.

THE DUST SPRAY.

Dust spraying has become quite popular in the Yakima valley, and has had many advocates. During our tests of 1905 the dust spray was given a competitive trial. It was then decided that a mixture of one part of Paris green to twenty of lime afforded the best mixture, but that the dust spray was somewhat inferior to arsenate of lead. The results of the former year are corroborated in a striking manner by the 60 per cent. of good fruit of the experiment this year. It may safely be asserted that the dust spray is unreliable in an excessively wormy orchard. The 750 windfalls of experiment 3 of table 1, represents the total number of windfalls from this tree while the picked apples were but about one-fifth of the fruit on the tree. In the other experiments the windfalls are proportional to the number picked from the trees.

It is of interest to note the cost of spraying this orchard. To spray the hundred trees required but a couple of hours,

COST OF THE TREATMENT.

but labor was paid for at half day rates. Many more trees could have been sprayed at but a slight advance in cost.

Team and driver, one half day, -	$2.00.
Two men, at $2, - - - -	2.00.
Arsenate of lead, 20 lbs., at 16c.,	3.20.
Total for each spraying, - -	$7.20.
Total for four sprayings, - -	$28.80.

In this case the investment of less than $30 insured a crop of 1200 boxes which sold for $1200. If the spraying had not been done the crop would have brought only $100 as

cider apples. The fruit from the fifty unsprayed trees was rejected by the buyer and was disposed of to the vinegar factory at the rate of twelve boxes for a dollar.

WHITNEY'S ORCHARD.

The orchard of C. L. Whitney comprises but a few hundred trees. No attempt has hitherto been made to suppress the codling moth as the trees have been kept for scions in Mr. Whitney's nursery rather than for their fruit. A part of this orchard lies in a low meadow land grown to alfalfa. The heavy frost that occurred at blossoming time destroyed most of the fruit of this portion of the orchard. The only fruit that set came from late blossoms, many of which were not yet open at the time of spraying. The low percentage of good fruit from these trees (experiment 7, table 2) bespeaks a good moral. Ordinarily the first blossoms are the ones to set. If these become frozen it will pay to repeat the first spraying for the tardy blossoms, or at least to time this spraying for their benefit.

The following table briefly indicates the results of spraying in this orchard:

TABLE II.

Exp. No.	No. Trees count'd	Variety	How Sprayed	Good	Wormy	Per Ct. Good
1	1	Yellow Transparent	2 sprayings	745	2	99.8
2	2	Wealthy	3 "	631	2	99.7
3	2	Red Cheeked Pippin	4 "	964	23	98
4	1	Jonathan	4 "	1489	33	98
5	1	King	4 "	739	86	90
6	1	Rome Beauty	4 "	225	9	97
7	3	Jonathan	4 " frosted	694	66	91
8	1	"	1st spraying omitted	319	291	52
9	1	"	Not sprayed	480	445	52
10	1	Rome Beauty	" "	52	240	17

The apples of experiments 1 and 2 were picked early, before the onset of the second brood. The low percentage for the King apple is relatively high for this variety. In our Yakima series of tests the King apple sprayed with Paris green ran about at 60 per cent. good when Rome Beauties ran at 96 per cent. This would indicate that arsenate of lead is a valuable spray for apples with an excessively waxy skin.

The well kept orchard of W. S. Offner represents an

average ranch under the charge of hired men. A positive effort has yearly been made to keep this place properly sprayed, but the lack of skill on the part of the workmen has resulted in losses of 15 to 40 per cent. The heavy freeze at blossoming time seriously affected this orchard also. The crop this year was light, and therefore more subject to worms, while much of the fruit came from late blossoms which were not in proper receptive condition at the time of the first spraying. Nevertheless even under these untoward conditions the results given in Table 3 clearly show the importance of proper spraying methods. The counts of these tables include a proportionate number of windfalls unless otherwise stated. Trees with a few wormy apples have a correspondingly small number of windfalls.

OFFNER'S ORCHARD.

TABLE III.

No. trees count'd	Variety	Treatment	Good	Wormy	Per Ct. Good
5	Jonathan	4 sprayings	4512	192	96.
4	Jonathan	Not sprayed	54	512	9.

The orchard of John Ross near the state line to the south of Walla Walla was selected for practical dust spraying. Most unfortunately for the experiment, but luckily for Mr. Ross, the dust machine was delayed so that the first spraying was given by Mr. Ross with liquid. This orchard of three hundred trees had been sprayed with a power sprayer the year previous. At picking time a careful estimate of several trees gave the following results.

THE ORCHARD OF JOHN ROSS.

1.—Yellow Newtown, with three dust sprayings, the first spraying not given, 5 per cent. free from worms.

2.—Yellow Newtown, first spraying of liquid, three subsequent dust sprayings, 60 per cent. good on the trees, but with many wormy windfalls.

3.—Rome Beauty and Jonathan, sprayed as number 2, 90 per cent. free from worms.

4.—Jonathan, not sprayed, 15 per cent. good.

The results here bear out what we have observed in the experimental dust spraying in the Lennon orchard. Dust should not be depended on to clean up a wormy orchard. In Mr. Ross' case 400 boxes were lost, 20 per cent. of his crop. This was a direct loss of $400 for his little orchard, most of which could have been saved by proper spraying. It will be recalled, moreover, that Mr. Ross gave the all-important first spraying with liquid. Otherwise his loss would have probably been much greater.

The advocates of dust spraying make much of the rapidity with which the dust can be applied. A liquid sprayer working at 200 pounds pressure can cover the trees nearly or quite as fast as the dust sprayer, while the comparative cheapness and cleanliness of the liquid spray are strong points in its favor. Eight hundred trees the size of those in Mr. Ross' orchard could be sprayed by our power outfit in a day, while it took practically a day to complete a dust spraying of his 300 trees after preparing the materials. The only important point in favor of dust spraying is therefore the cheapness of the outfit, but in a very wormy district the increased saving from worms, even in a small orchard, brought about by using a liquid spray, will pay for the spraying, power machine and all. A discussion of the effect of the dust spray on fruit is given further on in the paragraph on the Holcomb orchard at Wenatchee (page 13).

WENATCHEE CONDITIONS.

Although the codling moth has been present in the upper Wenatchee district for a score of years it is only recently that the pest has pervaded the valley. The codling moth is now considered a regular factor in orcharding, and every Wenatchee grower makes some effort to spray. Nevertheless, in those orchards where the moth has been present a half-dozen years the best determined efforts have saved but three fourths of the crop. The explanation for this is that growers have employed the old fashioned methods in vogue before they emigrated to Wenatchee. They have used low pressure pumps, and have aimed for a concentrated misty spray. They

regularly have given the second spraying ten days or two weeks after the first according to the old rule, and any subsequent sprayings have been given whenever convenient.

It was to demonstrate the value of experimental methods of investigation that we determined to apply the knowledge of the codling moth gained from the study of Washington conditions to the important apple district at Wenatchee. Two orchards were selected, the first where the moth had been present for many years, the other in the lower valley.

LANHAM'S ORCHARD.

Mr. Z. A. Lanham has had a hard struggle with the codling moth. His ten year old orchard has been regularly sprayed in what was generally conceded to be an approved manner. A gasolene engine pump, working at 140 pounds and fitted with Vermorel nozzles, was employed. The Eagle brand of arsenate of lead was used, in the proportion of three pounds to fifty gallons. In 1906 four sprayings were given yet the loss from worms was over 3000 boxes or 40 per cent. of the entire crop, according to the observations of the foreman and pickers.

This season we used the same Eagle brand of arsenate of lead, but in the proportion of one pound to forty gallons. We used a Bean power sprayer working at 180 to 200 pounds pressure. Each of the two extension rods was fitted with two Bordeaux nozzles set at an angle of about 45 degrees. This arrangement of the nozzles enabled us to throw the spray through all parts of the tree by simply twisting the rod. It is to this simple device that much of our success is due. The spray was rained on until the trees commenced to drip. At the first spraying we did not stop even then, but by the time we were satisfied that every flower cup was filled with spray, the ground beneath the trees was wet. To spray thus took from seven to fifteen gallons to each tree, whereas but three gallons or less sufficed for the second spraying, but even so we used much less arsenate of lead than had been put on the year before.

We had planned to test various spraying methods, such as varying the strength of the spray at the different spray-

ings. We also wished to compare with the older brands two new makes of arsenate of lead, Vreeland's and Lavanberg's. Vreeland's brand of arsenate of lead has a higher arsenic content than any other brand we know, containing over 20 per cent. of arsenic as compared with the 14 per cent. of the usual brands. Athough a dozen experiments intended to show the best strength of spray were carried on they gave no results for comparison. Throughout the tests the weaker spray gave as good effects as the stronger, and all the brands of arsenate proved alike in producing a perfecty clean crop. It may be emphasized as we have stated in previous publicaions that success depends not so much on a correct formula, nor, with the exception of the first spraying, on the exact timing of the sprayings, but altogether on the manner in which the spraying is done.

At picking time representative trees were stripped. The results of the tests have too much uniformity for comparison, and but reiterate the importance of proper spraying regardless of what brand is used.

TABLE IV.

Exp.	Formula	Brand	Good	Wormy
1	1:40, all sprayings	Eagle	1942	0
2	1:40, first; 1:50 others	"	1790	4
3	3:50, " 1:40 "	"	1323	4
4	1:20, " 1:50 "	"	1067	0
5	1:50, " 1:80 "	Vreeland	1325	1
6	1:80, all	"	2499	2
7	3:200, first; 1:40 others	Lavanberg	868	0

These tests were conducted in what was acknowledged the wormiest part of the orchard. The trees from which the counts were made were adjacent to a packing shed which had contained 1400 boxes of wormy culls the winter previous. Half of this wormy fruit was fed to stock during the winter. The remainder was kept in the shed until it decayed in the spring. At any rate whatever moths came from this mass of wormy fruit had every opportunity to lay their eggs on the very trees from which the counts were made. The foreman stated that in this portion of the orchard the

ground had been covered with wormy windfalls the year before, estimating that there had been nearly two hundred boxes of windfalls to the acre left on the ground when the crop was picked. This year scarcely a windfall was to be seen.

The relation of the wormy and good apples of the trees stripped and counted is one worm to 1000 apples, or one tenth of one per cent. The following letter from Mr. Lanham shows that the stripped trees were representative of the entire orchard, even though they must have received the eggs of thousands of moths from the shed that settled on them in preference to flying into the interior of the orchard.

Glencove Fruit Farm, Wentachee, 10, 31, 1907.

Prof. Melander: We have gathered our apple crop and marketed 5605 boxes, and by as careful an estimate as we could make, we lost not more than one tenth of one per cent. That, I consider, very remarkable, considering the great loss I had last year. You have certainly demonstrated the fact that the codling moth can be kept in check with proper spraying.

Very respectfully,

Z. A. Lanham.

This would place the loss from worms at but six boxes, an impressive contrast to the 3000 boxes lost the year before. 675 trees of the orchard were banded. The entire number of worms obtained from these bands this year was 178. Last year the same bands harbored over 100,000 worms.

The conclusion we can draw from this recital is that the first spraying was so thorough that every blossom was filled with poison. Since practically all the early worms seek to enter the apple at the calyx end, they were destroyed as fast as they came. This complete destruction of the first brood left no progenitors of the second and there were no late worms to blemish the apples. From the record this year at Wenatchee it would seem that the first spraying did all the work, and that not enough worms escaped to make the other three sprayings pay for their application. The truth of this assertion will be determined next season.

It may be of value to note the cost of this treatment.

THE COST OF SPRAYING.

The trees of Mr. Lanham are ten years of age, but are very large. At the first spraying they averaged 7½ gallons of spray. At the second less than three gallons were used. The increasing size of the fruit at the third and fourth sprayings required four to five gallons per tree. During a day eleven tanks, or 2200 gallons, were sprayed, the cost divided as follows:

Labor: Team and driver - -	$3.50
Two men, at $2.50 - - - -	5.00
Materials: Gasolene - - -	.80
Arsenate of lead, 44 pounds, at 16c.	7.00
	$16.30

The cost per gallon is therefore less than three-fourths of a cent. The 10-year old trees of this orchard averaged twenty gallons for the season's spraying, costing fifteen cents per tree. The entire spraying bill for this season amounted to $225. Last year but twelve gallons were used to each tree, but with Vermorel nozzles and the lower pressure it required a longer time to spray, and with the triple strength of arsenate of lead, this brought the cost of the season's spraying appreciably over $300.

Inadvertantly all the trees in Mr. Lanham's orchard were sprayed. Therefore as a check on the value of the

THE PENALTY OF IMPROPER SPRAYING.

spraying we must consider the results obtained in neighboring orchards. Otherwise those unfamiliar with the conditions might suppose that this was an off-year with the codling moth. For this purpose we prefer to quote from a letter received from the Special Horticultural Inspector for the Okanogan district.

"I consider the results obtained in the spraying demonstrations here wonderful. I had never before seen or heard of such results. I was present when the count was made and out of 11,000 apples only eleven were found wormy. I

inspected other orchards in the immediate neighborhood to compare results. At the Cox place, adjacent to the Lanham place, I roughly estimated the per cent. of wormy fruit to be about 50 per cent. This orchard had been sprayed several times but evidently not according to up to date methods. The Garrison place, within one-fourth mile from Lanham's had also about 50 per cent. wormy fruit. These results obtained by our State College officials are truly encouraging and they prove to me that any intelligent fruit grower need no longer fear the ravages of the codling moth."

Signed, P. S. Darlington, Special State Horticultural Inspector.

The Cox orchard of which Mr. Darlington writes had been sprayed four times for the first brood, but not for the second. Three pounds of arsenate of lead to fifty gallons, a hand pump of low pressure, and Vermorel nozzles had been used. The Garrison orchard had been given the first spraying only, and in the same way as at Cox's orchard. Such cases show that if spraying is to be worth anything it must be carefully done.

HOLCOMB'S ORCHARD.

The western half, including ten acres, of the orchard of the late B. B. Holcomb was selected as a representative commercial orchard. The largest part of this orchard was sprayed but three times, the usual second spray being omitted. The marginal five rows around the orchard were given four sprayings. The dates of the sprayings were May 15, June 20, July 23 and August 25. In this orchard a number of trees were sprayed with dust, in amounts varying from one pound to thirteen pounds per application. The object of this dusting was to find out if even excessive amounts of dust spray could produce perfect fruit. Finely screened dry slaked lime, twenty parts, and Paris green, one part, formed the dust mixture. At picking time every one of the dusted trees had a large proportion of badly distorted apples although all were comparatively free from worms. The amount of distortion was directly proportional to the amount of dust they had received. A tree sprayed with

thirteen pounds of dust at the first spraying and five pounds at each of the other three sprayings had more than one-half of its fruit rendered unsalable. A count was made of a tree dusted with 5:2:2:2 pounds at the various sprayings. 1501 good apples were found, 158 were so badly distorted as to be unsalable, and six were wormy. No distortion at all was apparent on the adjacent liquid sprayed trees. The abnormality consisted of a woodiness of the skin, which was often cracked deeply, after the manner of scorching from Bordeaux spraying. Many of the apples were soft and decayed throughout their lower half. The scorching obviously was caused either by arsenic poisoning from the Paris green or by dessication by the excess of lime. Apparently it was induced at the first spraying as it always manifested itself at the calyx end first. After the first spraying many blossoms which were sectioned showed that the dust had penetrated beneath the crown of stamens. It must be mentioned that the Wm. Turner orchard, where we obtained the sifted dust mixture, was dusted in part, the same material being used, and in this orchard there was no evident scorching. The trees of this place were dusted with the usual amount of about one-half pound to each tree.

Counts were made of a few liquid sprayed trees as they were being picked. The results of the spraying in this orchard are given in Table 5. It will be noticed that the Ben Davis number 2 was located in the middle portion of the orchard where the usual second spraying was omitted. Apparently in an orchard kept in a clean condition there is no need of giving this spraying if the first spraying be thorough. No account of the previous worminess of the Holcomb orchard is available. We know it has not been as near perfect as this year, but the place has not been considered a wormy orchard. The chief picker stated it was fully 20 per cent. wormy last year, while Mr. Holcomb did not suppose it went above five per cent. wormy. The Holcomb ranch has been regularly sprayed. Trees 4, 5 and 6 were picked early in the season, before the time of the last spraying. These trees are representatives as practically no apples were culled by the packers because of worminess, a clean record of 100 per cent. for the liquid sprayed trees.

TABLE V.

Variety	Treatment	Good	Wormy	Per Ct. Good
1. Ben Davis....	4 liquid sprayings	1878	0	100.
2. Ben Davis....	3 liquid sprayings	2087	0	100.
3. Ben Davis....	4 dust sprayings	1658	6	99.64
4. King............	3 liquid sprayings	3215	4	99.88
5. King............	2 liquid sprayings	546	5	99.08
6. Spitzenberg.	3 liquid sprayings	457	2	99.57
7. Jonathan	not sprayed	529	182	74.40
8. Ben Davis...	not sprayed	1132	57	95.21

ACKNOWLEDGEMENTS.

For the privilege of conducting these experiments we wish to thank the owners of the various orchards. We desire to thank the John Smith Company of Walla Walla and Messrs. Wells and Morris of Wenachee for generously loaning the modern Bean power sprayer, three of which we had in operation. Similarly we are indebted to the Wenatchee Produce Company for the use of a Gould's power sprayer operated by an air cooled gasolene engine. All the spraying was done by the authors or under their personal direction.

READ THESE SPRAYING DIRECTIONS.

Some conclusions of the greatest practical importance can be drawn from this season's observations. Briefly stated they are these. Practically every worm of the first brood attempts to enter the apple at the calyx end. If every calyx cup is filled with poison, practically every worm will therefore be poisoned. There will then be no second brood. But poison can be put into the calyx cup only within a few days after the petals have fallen. If it is not done then no amount of after spraying can force a thorough coating of poison into the calyx end of the apple, and the apples will become wormy. This fundamental principle must be understood if you wish success. In the foregoing pages we have shown that the first spraying CAN be so thoroughly applied that other sprayings are hardly necessary. This can be done by using much pressure, a coarse spray, a bent nozzle, and enough liquid to drench every blossom. Use arsenate of lead, and if you

spray thoroughly one pound to 50 gallons will be strong enough. Force the spray into every flower. This means that four fifths of your spray must be thrown down from above every branch, but it also means that you must spray in every other direction too. If the trees are tall it will pay to spray from a tower. Otherwise a bend at the end of the extension rod will answer. STAY WITH EACH TREE UNTIL YOU ARE SURE THAT EVERY BLOSSOM IS FILLED WITH SPRAY. That is what we mean by spraying thoroughly.

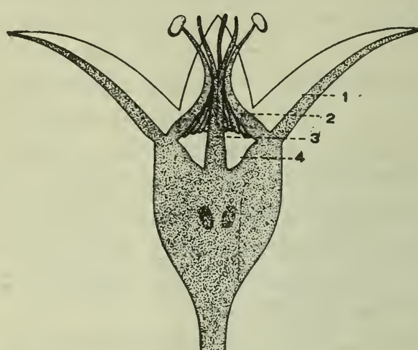

FIG. 1.—DIAGRAM OF THE FLOWER AT TIME OF FIRST SPRAYING.

The outer calyx cup (1) can be easily sprayed, but the fleshy stamen bars (2) and the branched pistil (3) make a tight capping over the inner calyx cavity (4) through which it is difficult to spray. Since most worms enter the apple at 4 the inner cavity must be thoroughly poisoned, and THIS CAN NOT BE DONE BY A LOW-PRESSURE MISTY SPRAY.

The first spraying must be done on time. Commence when about 85% of the white petals have fallen. If one pump can not cover the orchard in eight days get enough outfits to do so. If the orchard contains mixed varieties that do not blossom together, go over it more than once, spraying each variety when it is in best conditon. Never put off the first spraying. It must be done on time. We recommend to you to repeat this spraying in one week, and in the same way as before. This application will help insure thoroughness and will have more value than a spraying given at any other time of the year.

But if the first spraying is not thorough, so that you permit even a few first brood worms to live you will have

many of the second brood to endanger the fruit. Most of these worms also attempt to enter at the calyx, and here the value of the first spraying is again apparent. But as many of the late worms try to enter the sides it is necessary to keep every side of every apple coated with poison. A second spraying for the first brood and two sprayings for the second brood usually are necessary to accomplish this. At any of these sprayings spray until the apples just start to drip. You may use the same outfit as for the first spraying, or you may use lower pressure, Vermorel nozzles, and a straight extension rod. It is not necessary at these sprayings to spray from above the fruit.

For the last three years the second spraying, which is given when codling moth eggs are beginning to hatch, has followed a month to six weeks after the first. The third spraying should be given one month after the first worms appear under the bands. The effect of this spraying lasts three or four weeks, when the fourth spraying should be given.

These directions are simple. If you follow them you need have no dread of the codling moth. You can set out to have whatever number of worms you wish, just according to how carefully or how carelessly you give the first spraying.

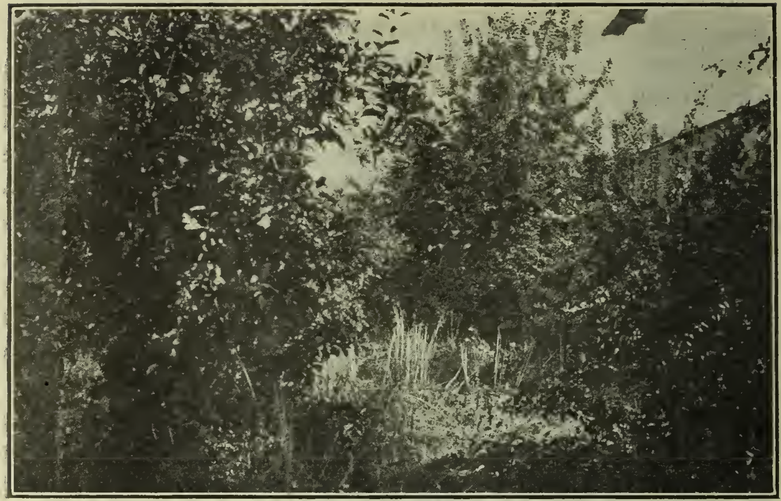

FIG. 2.—An abandoned orchard in the city of Walla Walla, scaly, wormy, unpruned, uncared-for, was changed in a single season to 99 per cent. and more of clean fruit by careful spraying.

FIG. 3—This orchard was considered such a failure that most of it had been cut down in order to grow wheat on the ground. This year $1000 worth of apples were sold from one acre of the remaining trees. The wheat barely paid the taxes of the land it occupied.

FIG. 4 —The large pile of apples to the left is wormy; the small pile is clean. These apples came from a tree in the part of the orchard that was not sprayed and were so wormy that it did not pay to sort them over. They were sold to a vinegar factory at the rate of eight cents a box.

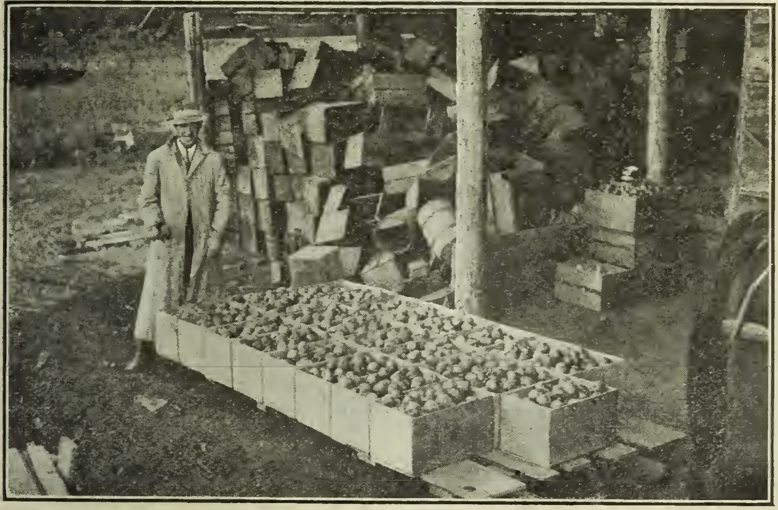

FIG. 5.—The man holds three wormy apples, all that weie found in 25 boxes. That is what 99.9 per cent of clean fruit means. The boxes in the background were fillea with wormy culls in 1906—and there were 3000 boxes full. This year careful spraying reduced the number of culls to six boxes in all.

LIST OF BULLETINS

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No. 1. Announcements.
2. Report of Farmers' Institute held at Colton.
3. " " " " " Garfield
4. Wireworms
5. Report of Farmer's Institute held at Pomeroy.
7. Two Injurious Insects. (The Pea Weevil and Cottony Maple Scale)
10. Wheat, Barley, Oats, Peas and Forage Crops.
11. Preliminary Report of Feeding Test with Swine.
25. Pruning Orchard Trees.
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31. Irrigation Experiments in Sugar Beet Culture in Yakima Valley.
32. Correction of Babcock Test for Cream, Effects of Richness of Cream on Acid Test.
33. Fiber Flax Investigation.
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35. Miscellaneous Injurious Insects.
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37. The Present Status of the Russian Thistle in Washington.
41. Grasses and Forage Plants in Washington.
42. A New Sugar Beet Pest and Other Insects Attacking Beets.
47. The Variegated Cut-Worm.
48. Mechanical Ration Computer.
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55. Washington Soils.
57. A Home Vegetable Garden in the Palouse Country.
58. Experiments in Feeding Swine.
59. Root Diseases of Fruit and Other Trees Caused by Toadstools.
60. A Report on the Range Conditions of Central Washington.
67. Some Notes Concerning Halpen's Test for Cotton Seed Oil.
68. The Wormy Apple.
69. Preliminary Report on the Codling Moth in the Yakima Valley.
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78. The Goat Industry in Western Washington.
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82. I. The Chemical Composition of Washington Forage Crops.
II. Analyses of Grains and Concentrated Stuffs.
83. Some Important Plant Diseases in Washington.
84. Wheat and Flour Investigations. (Crop of 1905)
85. Washington Soils.
86. The Codling Moth in 1907.

THE STATE COLLEGE OF WASHINGTON

Agricultural Experiment Station

Pullman, Washington

Department of

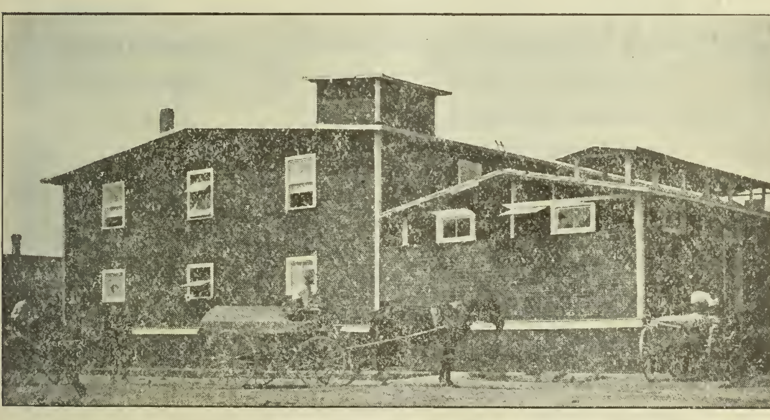
HORTICULTURE

Raspberries, Blackberries and Loganberries in Washington

BY W. S. THORNBER

Bulletin No. 87

1909



The Puyallup Summer Fruit Association Building. The center of the small fruit industry of that section.

Raspberries, Blackberries and Loganberries in Washington.

BY W. S. THORNBER.

INTRODUCTION.

Practically all kinds of small fruit can be profitably grown in nearly every part of Washington. Some localities are especially adapted to commercial production of berries or other small fruits. In others, such fruits are grown only for home use; but wherever other fruit is grown, either for home consumption or for sale, berries can be produced with equal success and satisfaction.

In several localities in this state, especially west of the Cascade Mountains, berry-growing has come to be a very important industry. The fruit grows to a perfection found in few other parts of the United States. The difficulties due to expense in picking and marketing the berries have been overcome by careful attention to the manner in which the berries are grown and by the formation of cooperative associations for marketing or preserving the fruit. The information contained in this Bulletin has been gathered largely from the experience of the most successful berry-growers in those localities and from the berry plantation on the Station farm at Pullman. While intended primarily for the grower of berries for commercial purposes, the suggestions are equally applicable to the home fruit garden, and may be relied upon to give profitable returns wherever they are made use of.

SOIL.

The raspberry and blackberry are two of our most cosmopolitan plants. Some form or forms of each are found in almost every climate and on practically all kinds of soil. True

it is they are partial to certain soils, yet no farmer in the state need be without berries if he chooses to grow them. A deep, well-drained, yet moist, sandy loam with considerable humus in it is the ideal soil. While blackberries do well on and apparently favor moist soil, raspberries are freer from winter injury on dry soil and rather favor it to the moister soils. If the soil lacks humus it should be supplied if possible either by green or stable manure before the plants are started, otherwise one will experience more or less difficulty in adding humus. Plant food may be added annually and economically to the soil by one of two methods. Either by growing cover-crops of vetch or peas between the rows and working them into the soil in spring, or by the hauling in of stable manures. The latter method combines two of our very important industries under one management, i. e., dairying and small fruit growing. However, the phase of fertility is not the only common ground of the two industries. They naturally travel hand in hand and where berries are grown, dairy cattle should be kept.

DRAINAGE.

If the soil is not naturally well drained artificial drainage must be provided, or success cannot be expected. Berry plants enjoy plenty of moisture but it must not be in excess. Many patches visited during the summer of 1906-07 showed evil effects of the excess of water at their roots. Land that is apparently dry enough during the summer months may be entirely too wet during the winter.

While studying the conditions of soil drainage the phase of air drainage must not be neglected. Evil results will come from poorly air drained plantations of berries just as surely as they will come from poor soil drained fields. This can be avoided by the use of properly adapted planting plans on sloping fields, and the removal of any obstructions such as hedges, fences, etc., that may tend to check the free circulation of the air down the valleys or over the flats. Plant diseases and insect enemies thrive best in the poorly drained field.

CULTIVATION.

Nothing can take the place of thorough cultivation. Careless or injudicious tillage ruins more fruit than all the insects and plant diseases together. "The price of successful fruit growing is eternal vigilance."

Cultivation is the most economical way of keeping down the weeds, of conserving the soil moisture, of preparing plant food for the plants and of improving the physical condition of the soil. These are vital considerations of berry culture.

The work of cultivation should start as early in the spring as the soil will permit and continue late into the harvest season. Many berry crops are cut short by the cessation of cultivation too early in the season. The early cultivation should be for the purpose of loosening up the soil to let the air in, while the later should be for the conservation of moisture, the killing of weeds and suckers and making plant food more available.

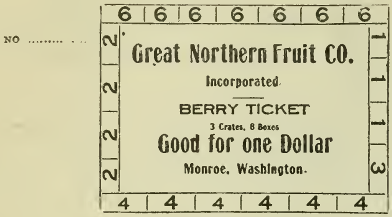
HARVESTING THE CROP.

Every commercial berry field should be provided with a conveniently located packing or cooling shed of some sort. It should be large enough to provide a place for the temporary cooling of the fruit as it is packed as well as some sort of a shelter for the packers and their crates.

One of the perplexing problems that most growers have to contend with is the securing of pickers. Many of the growers are solving this by providing suitable and pleasant camping grounds or living quarters, and securing boys and girls or even young people from the cities and nearby towns.

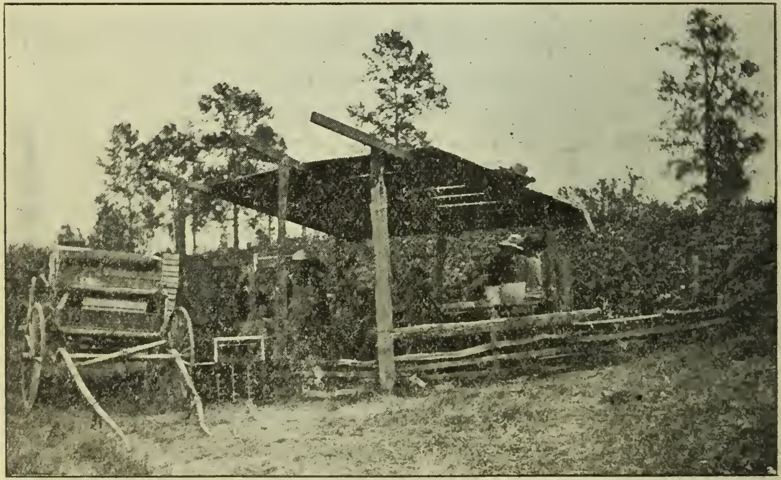
The methods of tabulating the work of the pickers is somewhat varied. However, most of the growers are using heavy manila tags upon which is printed the grower's name, a space for the picker's name and figures of various denominations to be punched as the required number of cups of fruit are picked. These tags are generally suspended by a string around the picker's neck and when all punched represent one

dollar's worth of labor. In many country places they are often passed at face value at the stores, redeemable on demand by the grower.


NO ....
6 | 6 | 6 | 6 | 6 | 6 | 6
Great Northern Fruit CO.
Incorporated
BERRY TICKET
3 Crates, 8 Boxes
Good for one Dollar
Monroe, Washington.
4 | 4 | 4 | 4 | 4 | 4

A shipping tag with this printing upon it makes an excellent "Pickers Tag"

Several forms of berry stands are used but probably the most satisfactory one is the low, legless one which is hard to upset and easily placed in the shade. Some pickers prefer the tall one; however, it is difficult to set in the shade and almost impossible to keep it from tipping over. One with short legs is frequently used; but it has few, if any, advantages over the flat-bottomed one.

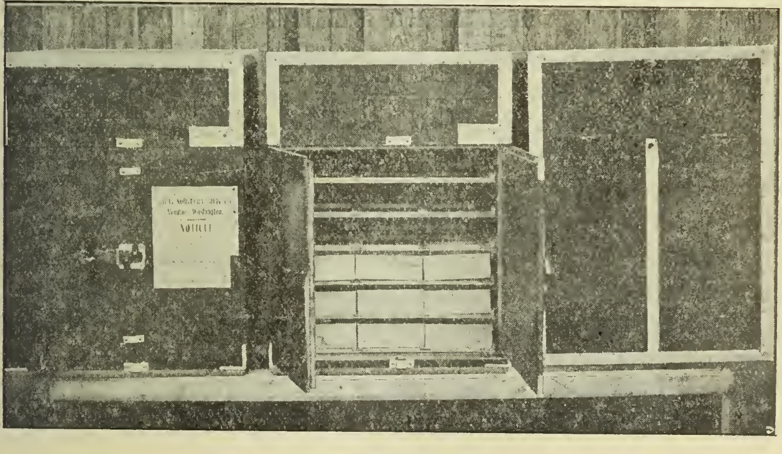


A temporary packing shed

A successful grower gives the following directions for picking:

"Raspberries should be picked when they are turning red. They will color and ripen in twelve hours, and will have as fine a flavor as if allowed to remain on the vines until entirely ripe. They should never be picked when wet or damp nor picked nor packed for shipment during the extreme heat of the day. If picked when warm, berries should be allowed to stand in the picking trays in the shade for a few hours before packing. The morning pick is the best long distance shipper.

"A rigid inspection of vines should be made by the field boss to see that no ripe berries are overlooked to be picked over-ripe at the next picking, as a few of these will spoil an entire case and may lower the grade of the entire shipment. The packer at the receiving shed should examine each tray delivered by the pickers to see that the berries at the bottom of the cup are as well picked as those at the top. Display on your receiving counter a cup of well picked and filled berries and call attention to it of all pickers who fall below the standard."



Pony Refrigerators, used for shipping small fruit long distances in limited quantities.

SHIPPING.

One of the drawbacks to the growing of soft fruits in many sections has been due to the difficulty of getting the fruit to market without serious if not total loss. The larger grower and the fruit associations solved this problem for carload lots. Other means had to be resorted to for the small or isolated shipper and as a result of this we have the so-called "pony refrigerator"—a small, light refrigerator that will hold fifty-four boxes of fruit, constructed in such a way that it can be sent by express, iced before starting and reiced once or more times on the road if necessary, and when empty returned to the owner or shipper to be refilled and sent out again. This has made it possible for small growers to ship quantities of soft fruit from the coast to St. Paul, Chicago and other central points and have it arrive at its destination in good condition.

Care must be exercised in the handling of fruit for long shipments. The fruit must be in prime condition when it leaves the field and not needlessly hauled over a rough road nor exposed to the sun for a longer period of time than is actually necessary. Over-ripe, soft, or wet fruit should never be shipped at all but be immediately consigned to the cannery, evaporator, or fruit juice factory.

PLANTING PLANS.

The distances that the plants should be set apart and the plan used is of more real importance to the berry grower than was formerly believed to be. Many berry plantations in Washington are now yielding poor or unsatisfactory crops simply because they are planted so close together that it is impossible to give proper culture and training. Like all other industries of a similar nature it is frequently abused by the over zealous grower. This close planting is not only responsible for poorly developed plants and therefore small unsatisfactory yields, but is also responsible to a very marked degree for the severe losses from insect pests and plant diseases. There is no condition more favorable to these pests than the crowd-

ing of plants together in large areas such as we find in Western Washington. Weak plants and poor air drainage are ideal conditions for all kinds of pests to secure a foothold and do much damage. The following reasons give some of the evil effects of close planting:

(a) Proper tillage cannot be given when the plants are crowded.

(b) The training of the plants and the harvesting of the crop is more expensive.

(c) Small unsatisfactory growth, hence light yields.

(d) Poor air drainage invites plant diseases.

(e) Crowding provides better breeding places for all kinds of insects.

(f) Increased expenses per acre for planting, care, training, and harvesting, without increased yields.

(g) Small, soft fruit as compared with large, firm fruit.

The soil, moisture, variety, and the nature of growth all tend to govern the planting plan used and the distance apart that the plants are to be set. For the convenience of this discussion the plants are grouped under two heads as follows:

1. **The Upright Growers.** These include the red raspberries and such of the blackberries as do not produce long vines, examples of which are Snyder, Ancient, Briton, etc.

2. **The Viny Growers.** Those plants producing long, trailing, recumbent vines so commonly seen in the Logan and Phenomenal berries and The Evergreen, Early Mammoth and Himalaya Giant blackberries.

I—UPRIGHT GROWERS.

There are two general systems, with numerous modifications, for planting the upright growers. These are known as the "Hill" and "Continuous row" systems. Each has its advantages as well as its disadvantages. The evils are apparently minimized in the former, while the latter system has a greater number of admirers but is more easily abused. The large growers apparently favor the hill system on account

A forty acre field of Red Raspberries near Monroe, Washington

of the advantages that it offers for the handling of large yields while the smaller planters usually favor the continuous row system for the simple reason that it lends itself more readily to close planting and heavy fertilizing.

Continuous Rows—This system takes its name from the fact that the plants are in continuous rows and while the indi-

Snyder Blackberry, one of the most productive sorts

vidual plants are farther apart yet it bears practically the same relation to bush fruit culture that the matted row system does to strawberry culture. The plants are set in rows from seven to nine feet apart and from two to three feet apart in the row. While this gives plenty of room for culture in one way it completely bars it in other directions. A large percentage of the first berry fields planted in Western Washington were planted in this way, while a majority of the new fields, and especially of the large ones, are being planted in the hill system.

Practically the only advantage that this has over the hill system is that it is possible to set more plants per acre and under favorable conditions harvest a few more crates of berries per acre. However, the grade is usually not as good as that of those grown by the other system.

It has a few very important disadvantages that should be carefully considered by every prospective grower. They are as follows:

1. Cultivation is possible in only one direction.
2. Air drainage is usually not so good.
3. A large portion of the plant is shaded more hours of the day.
4. In dense rows it is impossible for the pickers to secure all of the ripe fruit at each picking, therefore soft, unmarketable fruit will frequently find its way into the berry cups.
5. Diseases affecting the roots of the plants spread more rapidly in these closely planted fields than in other fields.
6. Diseases affecting the canes and fruit are more abundant in the continuous row than the hill system.

Hills—As the name implies, this system consists of growing the plants in hills rather than in continuous rows. The distances that the plants are apart will be governed somewhat by the fertility and variety of the fruit grown. A rank growing variety on rich soil should be planted from six to seven feet apart each way, while a weaker growing sort on fair to

poor soil need not be planted farther than five to six feet apart each way. However, as a general rule six feet apart each way, or 1210 plants per acre, gives satisfactory results for most varieties, soils, and purposes. Some of the finest and most productive patches in Western Washington are planted in this way.

The hill system has one apparently serious drawback in that it reduces the number of plants possible to set per acre, from 1840 where planted 3 by 8 feet to 1210 plants where planted 6 by 6 feet. To the average advocate of the hill system this is no drawback, as he is more than able to make up in quality and grade what he loses in quantity. The following advantages are very apparent in this system:

1. Room for thorough tillage with horse cultivators each way and even diagonally if so desired.

2. Room for pickers to see and secure all fruit as it ripens; therefore, the elimination from the cups of soft, unsalable fruit.

3. The maximum amount of sunlight—which is essential for the formation of large buds and the development of the highest quality and best size of fruit.

4. Necessary room for proper pruning, thinning, training, etc.

5. Economy and simplicity of supporting the canes.

6. A more nearly perfect air drainage, which tends to minimize if not eliminate the dangers of late spring frosts and much of the loss caused by bacterial and fungus troubles.

II—VINY GROWERS.

As a matter of convenience we have grouped the Evergreen, Mammoth and Himalaya Giant blackberries and Logan berries and called them the viny growers, since they produce long recumbent, climbing, or trailing vines. From the nature of their growth they require an entirely different planting plan and system of training to make satisfactory cultivation and picking possible. Eight feet is a reasonable distance

Evergreen Blackberry, the latest and most productive variety in cultivation

apart for the rows, but the plants in the row require intervals of from sixteen to twenty-four feet, governed entirely by the fertility and moisture determinants. In good rich soil with the proper amount of moisture it is not uncommon to find canes or vines from fifty to sixty feet in length, while on dry or poor soil they may not be more than four or five feet. Other things being equal the longer and stronger cane that can be grown the more productive will be the field. Many of the early planters made a mistake in using the opposite instead of the alternate system of planting. It is only reasonable to assume that strong feeding plants will sooner or later begin to crowd one another when planted not more than eight feet apart and therefore for this reason we find it advisable to use the alternate row system.

BERRIES AS FILLERS IN YOUNG ORCHARDS.

The practice of using berries as fillers in a young orchard is one that requires careful consideration. It involves the same principles that the use of fillers in any orchard does and can be fairly treated only from a similar point of view. The profitable use of fillers depends more upon the man that uses

them than upon any other single consideration. While it is a safe proposition for some men, it is extremely dangerous for others. The arguments may be well summed up in the following manner: Fillers are a good thing in an orchard so long as they stimulate better tillage and in no way interfere with the growth or management of an orchard. But under no consideration must they be permitted to remain long enough to interfere with the pruning, fertilizing, spraying, thinning and harvesting of the orchard crops. The man is rarely to be found who will remove a good healthy productive filler before it does serious injury to the permanent tree. So long as this condition lasts the general use of fillers will always be attended by more or less risk.

There are two general systems of planting berries as fillers in the orchard. One consists of adapting the continuous row system to orchard conditions and the other by making use of the hill system. Both systems are successfully used at the present time. However, for various reasons the Hill system carried out in the following manner is preferable: Plant the fruit trees thirty-six feet apart using the alternate system and set the berry plants six feet apart between the fruit trees in the rows as well as between the rows. This will allow the planting of 1180 berry plants and thirty fruit trees per acre.

This method of planting minimizes the evils of fillers in an orchard and if properly cared for and the bushes removed as the trees require the room large quantities of small fruit may be raised in conjunction with the growing of the orchard trees. After the third or fourth years all berry plants within six feet of the fruit trees must be removed without fail and the fourth or fifth years those berry plants situated diagonally on the same squares with the trees must be removed and so on until all berry plants are out. In so doing the trees are given abundance of room as they require it and no evil should result from the use of fillers.

Where the conditions of soil and climate are favorable for each, this is an excellent plan to use in connection with

the growing of English walnuts. Since walnut trees are grown with longer stems and require little or no spraying they are much more adapted to use in connection with small fruit than the ordinary orchard tree.

TRAINING AND STAKING.

The manner of training and staking is largely governed by the varieties, system of planting, and the method of tillage. No single phase of berry culture requires a more careful consideration than that of training and staking. The neglected patch is a thing of the past and the up-to-date culturist no longer expects to gather successful crops without giving special attention to training. The conditions that exist in Western Washington have been productive of almost a revolution in the methods of berry culture and while this is more noticeable in the methods of training than in any other particular yet wonderful strides have been made in all directions.

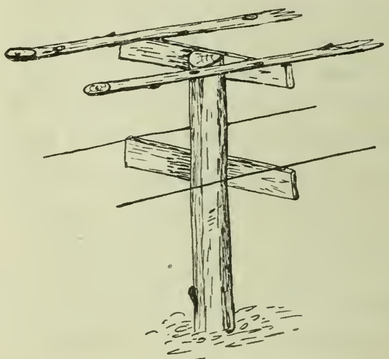
There is practically only one system to follow for training the upright growers when they are planted in hills and that is to set a light post from five to six feet high at each hill. From five to seven canes are trained up and tied firmly to this post until they reach the top when they are topped and are permitted to throw out laterals. This produces a well-supported compact hill that can be easily cared for with a horse cultivator and gives the fruit every opportunity for its fullest development as well as simplifies picking very materially.

A grower at Sumner employs an interesting and very successful method of training his Snyder blackberries which are planted in hills six feet apart each way. Instead of using one light post at each hill he sets two from twelve to eighteen inches apart. While one post is supporting the fruiting canes the growing canes are being trained upon the other and any one familiar with the Snyder blackberry will at once see that this simplifies picking and training materially even though it does increase the initial cost of staking.

Whenever the continuous row plan of planting of upright

growers is followed, some form of lateral support is necessary to keep the canes from leaning over into the spaces between the rows and interfering with cultivation and picking. Various materials from heavy wire to light alder or even cedar rails are employed for this purpose. The best plan is to set a single line of posts about sixteen feet apart and from five to five and one-half feet high through the middle of the row. At three feet from the ground and at the top of these posts nail one by three-inch cross arms eighteen inches in length. Along the outer and upper corners of these arms heavy (preferably No. 10) wires are stretched. This gives two wires on each side of the row and forms an excellent simple method for training this kind of canes.

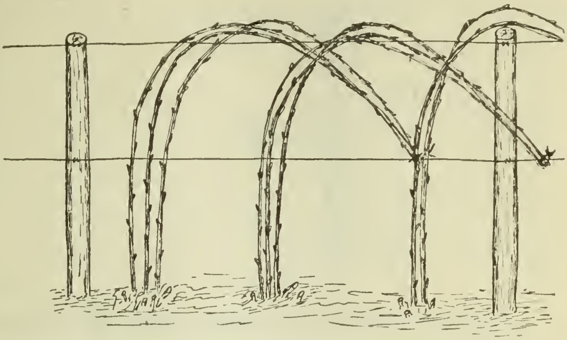
A good framework for supporting the canes of Red Raspberries.



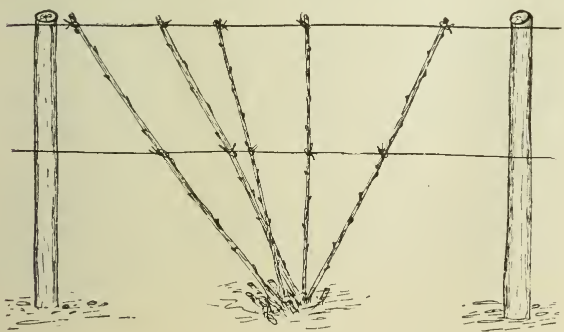
Another method that is frequently employed consists in setting light posts 16-18 feet apart in pairs one on each side of the row and then fasten these together with two cross bars. Upon these cross bars light rails or poles are laid to support the canes much the same as the wires in the former plan. The principal advantage of this plan is that the poles do not injure the canes as much as the bare wires.

A grower at Snohomish uses a very satisfactory method for his raspberries. The plants are at intervals of three feet, in rows eight feet apart. With his conditions of soil and cultivation he is able to produce canes from twelve to sixteen feet

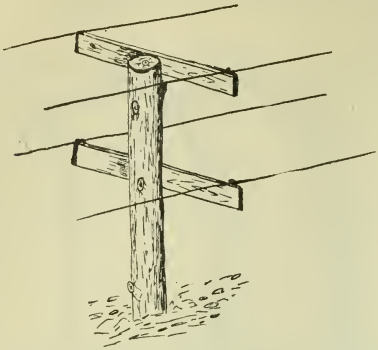
The way one man handled his 12 foot canes of Red Raspberries



high and does not top them until he is training them on the wires some time during the winter. His system of training consists of setting a single line of posts six feet high, 16-18 feet apart through the middle of the row. Two strong wires are attached to these posts, one at the top and the other three feet from the ground. The canes from one hill are gathered together and gently bent over until the tips touch the lower wire usually about six feet from the plant or opposite the second plant, where they are firmly tied to the wire. The next plant is likewise treated in the same manner all the canes leaning in the same direction and so on throughout the row, in fact the whole patch is trained in the same direction. The simplicity, ease of handling, and the great amount of cane that can be saved in this manner, recommends this system to many.



A good way to support the canes of small fruits in windy locations



The best form of support for vine producing sorts

Those varieties producing long recumbent or trailing vines require horizontal support to make cultivation and picking possible under any circumstance. Undoubtedly the most satisfactory method for our conditions consists in setting a single line of posts five feet high and sixteen to eighteen feet apart in the rows. To these posts nail two eighteen-inch cross arms, one at the top and the other three feet from the ground and at the ends of the cross arms fasten four No. 10 wires. This provides four wires for each row. The two upper wires act as cables for the growing vines while the two lower ones serve as supports for the fruiting vines. As soon as the strong shoots reach the upper wires they are carefully trained below them and supported by soft string. The growing tips must always be kept in an upright position or the cane will throw out many undesirable laterals.

When ready to lower the canes from the upper to the lower wires small 1 by 1 inch strips twenty inches long and notched at each end in such a manner so as to fit over the wires, are placed upon the lower wires from eighteen inches to two feet apart. These strips form a support for the canes as they are lowered and are easily removed during the process of cleaning up and pruning.

The process of lowering the canes is easily accomplished by cutting the cords which support them and simply permitting them to rest upon the 1 by 1 inch strips. This leaves the upper

wire again free for the training of the new crop of shoots and when the proper time comes these in turn are lowered for fruiting on the lower wires.

While the system may seem complex and more or less difficult to handle yet it is very simple and has many valuable features even though it does require a little extra time during training season. Some of the especially valuable features are:

1. That the growing canes are separated from the fruiting canes thus making picking much easier.

2. The growing canes being above receive full benefit of sun and for this reason produce better canes, shoots, and buds.

3. The process of pruning is simplified a hundred per cent.

4. It makes possible the growing of a greater number of plants per acre than the ordinary method.

These varieties are sometimes trained upon a two-wire system much the same as grapes but this compels the fruiting canes and growing canes to grow together, which is always a very undesirable feature.

PRUNING.

The work of pruning berries naturally divides itself into three heads: First, the removal of the old canes which should take place at the close of the harvest season; second, the pinching back or summer pruning which is done during the growing season; and third, the removal of surplus wood which should be done late in winter or early in spring.

Practically all growers agree upon the method and time of removing the old fruiting canes realizing of course that they are of no more use to the plant and that further incumbrance simply means an excellent harbor for insect pests and plant diseases. In tender varieties it is sometimes thought best to let them remain until the regular pruning season of early spring in order that they may act as a protection to the young canes.

Upright Growers—The question, "At what height do you

pinch back your young raspberry canes,'' was asked a large number of berry growers. The replies varied with the locality, the man, and the system of training followed, from no pinching back up to eighteen inches. However, a large proportion of the growers west of the Cascade mountains expressed the opinion that from four to five feet gave the best results for their conditions. When the canes are pinched back at this height it tends to produce firm wood which is seldom injured during the winter season.

In certain fields where the canes were pinched back at less than four or five feet they produced rather long laterals which failed to thoroughly ripen up before winter and during the course of the winter were severely injured or even killed, while in those fields where the canes were ''pinched back'' high, or not at all, the wood apparently ripened earlier and suffered little or no injury. The probable reason for this is that the early pinching back tended to throw the plant into active growth again rather than permit it to assume a semi-dormant condition.

In localities where the maximum growth does not exceed four or five feet ''pinching back'' at eighteen inches or even no pinching back at all has proven very satisfactory.

Another very important phase is the regular and systematic removal of all suckers during the early part of the season, and careful thinning when they are left for the future crop. Some growers keep the suckers out until the middle of June. While this is advisable as far as the present crop is concerned it is rather late to be sure of producing good canes before the summer drouth comes on severe enough to injure them.

Viny Growers—The vine producing sorts present rather a different phase of pruning. Instead of ''pinching back'' we endeavor to produce the required number of canes per hill, usually four, and have them as long and strong as possible with a minimum number of laterals. In fact most growers

recommend the removal of all laterals. Late in winter or early in spring these long canes or vines are cut back from one-fourth to one-third their length. The stronger the canes are at this time the longer and better will the fruit shoots be.

The Blackcap varieties of raspberries should be pinched back early in the season in order to compel them to produce a strong framework for the support of the laterals and their shoots. Usually two or more pinchings are necessary to produce good plants of the cap sorts.

DEWBERRIES.

The Dewberry is one of our recently introduced fruit plants and while closely related to the blackberry it can be grown on a greater variety of soils and more severe climates than its tall relatives, the common blackberries. It is especially adapted to our gravelly soils where plenty of water can be supplied during the fruiting season. Its trailing habits makes it possible to grow it where the winter weather is too severe for the common blackberry since it is easily protected by a light mulch of straw .leaves or any coarse litter.

The Dewberry should be planted in hills at least six feet apart each way and given the same general culture that raspberries or blackberries are given. It requires no summer pruning aside from the removal of old fruiting cane after the crop is harvested and while it is generally grown without supports better results can be secured by staking and training to a single stake.

The Lucretia Dewberry is the only variety that has given desirable results thus far in our work at the Station. But this one has been a splendid success in every particular. The fruit is large, rich, juicy, and of excellent quality. It ripens from a week to ten days earlier than the blackberry and withstands dry weather much better. It is naturally very productive and has brought good prices in all the markets during the past three years.

VARIETIES.

The following list includes only such varieties as are found in home gardens and commercial plantations. These notes, upon which the conclusions are based, have been collected from all parts of the state, thus making them more general than if secured in any single locality:

"The Cuthbert" The best general market Red Raspberry

RED RASPBERRIES.

Cuthbert—A chance seedling found by Thos. Cuthbert in southeastern New York in 1865. The plant is one of our best growers, practically free from insect pests and plant diseases. Adapted to adverse conditions of all kinds except excessive moisture when it occasionally winter kills. Its deep rooting nature makes it one of our best dry land raspberries. The canes are tall, clean, and strong, and can be trained to single stems or pinched back and made to branch. The fruit is firm, large, bright red, slightly conical, of excellent quality and stands shipping remarkably well. While it is not as early as some varieties yet it has a much longer fruiting season and is more productive than the average. Considering it from many

A fruiting branch of the "Cuthbert"

points of view this is the ideal market berry.

Crimson Beauty—Found growing in a patch of Imperials by Dr. Stayman of Leavenworth, Kansas. The plants are strong erect growers, practically free from insect troubles or plant diseases, but never produce tall canes. The foliage is good, dark green, plentiful, and healthy. The fruit is large, round, of a bright crimson color, but entirely too soft to be of commercial value, and while it ripens very early and its season is comparatively long a large portion of the berries are poorly formed and irregular, due at least in part to insufficient pollen at blooming time. If the fruit is picked before it is dead ripe it crumbles badly and if it is not picked as soon as it is ripe it drops so there is loss in either case. As a whole the variety is not profitable either for home or market use.

Improved Superlative—This is one of the new raspberries in western Washington and while it has not been generally tested in many localities yet wherever planted it has proven very satisfactory. The canes are clean, strong, early maturing, and very productive. The fruit is large, of a dark crim-

A fruiting branch of the "Antwerp"

son color, firm, and of fairly good quality. It ships and sells well and on account of its deep rooting nature it endures the dry summers and cold winters better than most varieties.

Marlboro—Originated by Mr. A. J. Caywood of Marlboro, N. Y., as a result of several crosses with both tame and wild sorts. The plant is an exceptionally strong grower and while not as tall as some varieties yet its few strong canes are frequently more productive. The foliage is dark green, more or less rugose, and entirely free from disease and insect troubles. The fruit is round, light red to pink red, very showy, juicy, rather firm but sometimes crumbles. It is not rich in quality, but a very good market sort in many places. Its season is medium to early and usually very long but not so productive as the Cuthbert. While it is quite hardy it is not adapted to all kinds of soil nor yet to the extreme hot sun of some places.

Philadelphia—The original plant was found growing wild almost within the limits of the city of Philadelphia over sixty years ago. It is not a tall grower and produces few canes, but these are strong and branch readily thus forming a nice bush.

The foliage is good, dark green and healthy, and practically free from insect pests and plant diseases. The fruit is rather small, very soft, purplish red, very juicy and of good quality. It begins to ripen the last of June and has a long season but is frequently seriously injured by the dry weather causing the fruit to drp up and drop before maturing. The plants are very most productive variety we have it is not suitable for com-

Marlboro Raspberry, a valuable variety for most rich soil

productive but on account of the small berries and low growing habit of the canes picking is slow and tedious. While it is the mercial planting nor do we recommend it for home planting.

Red Antwerp—Probably the oldest red raspberry in cultivation at the present time. It is a native of Europe that has been distributed under many names. While it is a standard of excellence wherever raspberries are grown great care must be exercised in the selecting of plants for new plantations in order to avoid diseased or weak plants. Many plantations of the Antwerp show signs of weakness and disease. This must be carefully guarded against or we will soon lose this very valuable sort. By a little careful selection of the plants to be used in new plantations it is possible to secure strong product-

"The Red Antwerp" the best early commercial red Raspberry

ive plants that are practically free from disease. Wherever the Antwerp succeeds, it is medium to early, very productive and has tall vigorous healthy canes, and good strong foliage, The fruit is large, slightly conical, dark red, with a dense bloom, moderately firm and has a brisk vinous flavor. It ships well and is very popular in the market.

Ruby—A seedling of the Marlboro originating near Marlboro, New York, about ten years ago. Although of recent origin this variety is rapidly becoming known as one of our best red raspberries. The plants are strong free growers, with plenty of coarse dark green foliage. The fruit is very large, bright red, of excellent quality, ships well, and is becoming very popular in many markets. It begins to ripen the last of June, continues to fruit over a long season and is not readily injured by hot dry weather. During the past three years this has been our best red sort.

Turner—Originated by Prof. J. B. Turner of Jacksonville, Illinois, about seventy-five years ago. The plants are extremely hardy, very rank growers, and entirely free from plant troubles. The foliage is dark green and practically free from

insect pests and plant diseases. The fruit is large, soft, juicy, bright red, sweet to sub-acid and of fair quality. It begins to ripen the last of June but is soon affected by the dry weather causing it to dry up or drop early. While the fruit is too soft for shipping yet this is a valuable sort for severe situations and early fruit for home use.

YELLOW RASPBERRIES.

Caroline—Originated by S. P. Carpenter of New Rochelle, N. Y., from seeds of the Brinkle's Orange. The plants are fairly strong, erect, entirely free from insect pests and plant diseases, but not as rank growers as other varieties. The foliage is good, dark green, and abundant. The fruit is medium sized, almost round, yellow, with a faint tinge of red, very juicy, tart, and entirely too soft to be of commercial value. The plant is very productive and if given the best of care will produce a fair grade of fruit but it soon deteriorates if neglected. Like all other yellow fruited varieties it is not profitable as market sort, there being no demand for yellow raspberries.

Golden Queen—A yellow fruited form of the Cuthbert found by Ezra Stokes of Berlin, N. J. The plant and canes closely resemble the Cuthbert but do not seem to be quite as thrifty or as productive as the Cuthbert. The fruit is roundish oblong, firm, of a clear yellow color, of excellent flavor, rather sweet, and stands shipping remarkably well. But there is practically no call for a yellow raspberry in our markets and while it is excellent for home use it should not be planted for market purposes. Its season of ripening is about the same as the Cuthbert.

BLACK RASPBERRIES.

Gregg—Was found wild near Aurora, Indiana, by Messrs. R. and I. Gregg for whom it was named. It is probably our most popular and best known black-cap raspberry and while it has the undesirable habit of varying in fruiting season and size of fruit yet this can in a measure be avoided by careful

selection of planting stock. The plants are vigorous, free from disease, hardy and very productive. The fruit is medium to large, black, firm, rather dry and sweet when fully ripe. It is very popular as a market berry and for drying purposes. When grown on moist land it is sometimes troubled with anthracnose and occasionally winter kills but this is not true when grown in dry land.

Kansas. Originated by Mr. A. H. Griesa, of Lawrence, Kansas. This is considered one of our best black cap varieties, due in part to its vigorous, strong canes and plants which make it very desirable, and also its resistance to disease, summer drouth and severe winters. Its fruit is medium to large, of a dark purple color, and fair quality. It ripens about a week earlier than the Gregg, is very productive and ranks very high either for home or market purposes.

Burkhart. A chance seedling found about eight years ago, upon the farm of Rev. F. Walden, of Zillah, Washington. The stock was turned over to M. E. Burkhart, who named the plant and is now disseminating it. It is supposed to be a seedling of the Gregg, which it resembles in some ways, but is far superior to it in others. The plant is very strong, a rapid grower, has plenty of large, dark green leaves and is free from diseases. Its strong, deep-growing roots enables it to withstand the drouth better and continue to bear long after other sorts have dried up or ceased to be productive. The fruit is large, pure black, firm, of excellent quality and is borne in large bunches. The plants are very productive. For the past three years the Burkhart has been the best black cap in our plots. It is one of the most promising new sorts that has been introduced in years.

Mammoth Cluster. Originated from the old Miami at Collinsville, Ind. It has been sold under various names, the most common of which is the McCormick. It is thought by some to be the largest and best black cap in cultivation but

most growers seem to favor the Gregg. The plant is strong, vigorous, and very productive. Its fruit is large, firm, juicy, dark purple, black and sweet.

Ohio. It is not definitely known when or where this variety originated. But it has attracted wide attention as a market berry in many parts of the United States. While it is valuable for use in its fresh condition, its main value seems to be in its adaption to evaporating purposes. On account of its extreme seediness, more pounds per bushel of dry material may be secured from this variety than from any other raspberry. The plant is strong, vigorous, hardy, and productive, while its fruit is large, dark purple black, firm, of good quality and ripens from the middle to the last of July, being what is generally termed a medium season berry.

A spray of "Evergreen Blackberry"

BLACKBERRIES.

Early Mammoth. A supposed hybrid of the Wilson blackberry and the Eastern dewberry. The plant is a very vigorous grower of the viny group, frequently producing vines twenty

to twenty-five feet in length in a single season. While it has not been fully tested, it has proved itself to be the earliest blackberry in cultivation. The foliage is good, plentiful, and free from pests. The fruit is very large, pure black, rich, juicy, sweet, and of excellent quality. It is probably too tender for exposed or severe situations but does well west of the Cascade mountains.

Evergreen, or Oregon Everbearing Blackberry. The origin of this plant is a much mooted question; however, it is probably a form of the common European Rubus fruticosus. It is a very vigorous grower of the viny group whose canes are more or less perennial in mild climates. For many years it has been used as an ornamental plant on account of its semi-evergreen habit and beautifully cut foliage. The fruit is medium to large, black, ships well and of excellent quality. It is our best late and most productive sort.

Himalaya Giant. Originated by Luther Burbank from seed secured in the Himalaya mountains. It is a very rank grower of the viny group, frequently producing canes from twenty to thirty feet in length and resembling in many ways the Evergreen blackberry. The fruit is medium sized, black, juicy, of good quality, and ships remarkably well. It is borne in clusters which make picking easy and the plants very productive. The deep rooting habit of the plant and earliness of its fruiting season both tend to make it a valuable sort for commercial work. While it has never been given a satisfactory trial at the Station, we are of the opinion that it would tend to severely winter kill.

Kittatinny. Supposed to have originated from a chance seedling found in the Kittatinny mountains of New Jersey. It is one of our oldest varieties of blackberries and, while a very popular sort, it is not entirely hardy in most parts of the state. The plants are fairly vigorous, moderately productive, but very subject to rust. The fruit is very attractive, black, juicy, pleasant flavored, and very good in quality. It should not be

planted in any but the western part of the state.

Snyder. A variety found growing wild in northern Indiana over fifty years ago. It is one of our oldest and most reliable market varieties and while it has certain objectionable features, such as sunburn and blackberry blight, in certain localities, yet there is no other single variety that fills the place now held by the Snyder. It is an erect grower, producing tall, vigorous, healthy canes, with large strong foliage. The fruit is medium sized, from brownish black to pure black, juicy, pleasant flavored, of good quality, and ships well. Under favorable conditions it is early and very productive.

Stone's Hardy. A chance seedling found about twenty years ago. While it resembles the Snyder in many respects yet it is not so popular nor commonly grown. The plants are strong, vigorous, hardy, upright growers but not average as tall as the Snyder. The fruit is medium sized, juicy, almost black, and of good quality and flavor. Where it is not possible to grow some of the more productive late sorts this variety should be given a trial.

HYBRIDS.

Logan Berry. A hybrid of the Red Antwerp raspberry and a native blackberry or dewberry of California produced by

"The Loganberry"

Judge J. H. Logan, of Santa Cruz, Cal. This is a remarkable plant in all parts of Washington for productiveness, hardiness, freedom from disease and insect pests, and ability to withstand drouth. It is a rank, coarse grower, producing long viny canes and large healthy leaves. It occasionally kills back in the winter but this can be avoided by slight protection. The fruit is very large, frequently an inch and a half to one and three-fourths inches in length, shaped much like a blackberry and of a dull crimson-red color. Its flavor is a combination of the flavors of its parents and while some people do not care for it others prize it very highly, not only in its fresh state but also for canning, jelly, etc. It ships well if picked before it becomes dead ripe. The plants require severe pruning in order to keep them in shape and systematic training to make picking possible.

Phenomenal Berry. A hybrid of the Cuthbert raspberry and a native dew or blackberry of California produced by Luther Burbank of California. The Station has not had the opportunity to give it a fair trial as yet but comparative tests are now being made. The plant resembles very closely the Logan Berry. Growers who have produced it side by side with the Logan Berry in western Washington pronounce it superior to the latter in color, flavor, hardiness, vigor, shipping quality and picking season. It is said to take on more of the raspberry flavor and is decidedly more desirable for general purposes.

State College of Washington

Agricultural Experiment Station

Pullman, Washington

DEPARTMENT OF CHEMISTRY

I. Lime as a Fertilizer, by R. W. Thatcher

II. Farm Practices in Applying Land Plaster in Western Oregon and Western Washington, by Byron Hunter

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PART I.

Lime as a Fertilizer

By R. W. THATCHER.

Lime in one form or another is almost universally used as a fertilizer. Its value for this purpose has been known for many centuries, as early Latin writings show that liming of the soil was practiced by the Romans more than two thousand years ago. In many European countries liming of soils has long been, and is still, regularly practiced.

BENEFICIAL EFFECTS OF LIME ON SOILS.

Lime as a fertilizer may act either directly as a plant food itself or indirectly by rendering other plant food more available.

As a plant food itself, lime is essential to all forms of plant growth, being utilized some way by the plant to aid in the production of cell-walls or woody fibre material. If lime should be wholly lacking in any soil, even if all other essential elements were present in abundance crops could not make normal growth on it. This is particularly true of the legumes or clover crops of all kinds, including peas, beans, vetches, etc. The amount of lime required per acre for such crops is nearly, if not quite as large as their potash requirement, and for such crops lime as a direct fertilizer is just as

important as any other of the elements which are more commonly used for fertilizer purposes. Very sandy soils, or those derived from granite rocks are particularly apt to be deficient in lime, and the fertility of such soils, especially for the "lime-loving" crops mentioned above, may often be materially increased by the application of some form of lime in which it is immediately available to plants.

The amount of lime required as plant food by most crops other than legumes is comparatively small, however, and there are very few soils which need the application of lime for plant food purposes for ordinary field crops. But as an indirect fertilizer lime is beneficial to a great many different types of soils and for a variety of purposes.

Lime may act beneficially on soils either chemically or physically or both. Chemically, it neutralizes acidity (or "sourness"), aids bacterial action especially nitrification, and helps to liberate other elements of plant food from unavailable forms. Physically, it improves capillarity and increases the water-holding capacity of nearly all kinds of soils, tends to improve the friability of clay, and to prevent washing of silt or sandy soils. When vegetation decays it produces organic acids. In soils deficient in lime these acids may accumulate in such quantities as to be injurious to crops. Many agricultural plants are especially sensitive to such acids and grow very poorly on "sour" soils. Lime, in either the caustic, water-slaked or air-slaked forms will combine with and neutralize the harmful effect of these acids, thus greatly improving the fertility of the soil, provided it is sufficiently supplied with other necessary elements of plant food.

Furthermore, the bacteria which cause decay and fermentation in the soil, rendering all forms of plant food more available, work best in soils of neutral or alkaline reaction, and also need lime for their own plant food requirements, hence a sufficient supply of lime is necessary in order to insure this beneficial bacterial growth. This is particularly true of the

bacteria which cause the change of nitrogen in decaying vegetation into the forms in which it is available to plants. This process (known as nitrification) consists in the breaking down of the complex organic materials which are present in the decaying vegetation or humus, and changing of the nitrogen which they contain into nitrites or nitrates, in which form it can be taken up through plant roots and used as plant food. These changes proceed by several different stages, each one of which is brought about by certain definite bacterial growth. Since nitrogen is unquestionably one of the most essential, if not the most critical, element of plant growth, and since it can become available in the soil only through bacterial action, which in turn depends upon the presence in the soil of a sufficient amount of lime to supply favorable conditions for bacterial growth, the importance of lime in the soil as an aid to the process of nitrification can hardly be overestimated.

The addition of lime to soils containing potash in unavailable forms results in liberation of the potash in forms in which plants can use it. In soils deficient in active lime, the phosphoric acid originally present or that added as fertilizer may combine with iron or alumina and form compounds in which it is of very little or no use to plants. The addition of lime to such soils prevents the formation of such compounds and may, in part at least, free the phosphoric acid from such combinations if already formed. The beneficial action of land plaster on many western soils is doubtless explained by its effect in liberating potash and phosphoric acid from unavailable forms. Laboratory tests on such soils have shown that small amounts of land plaster, or gypsum, are very active in rendering nitrogen, potash, and phosphoric acid soluble in soil water, thus making them easily available as plant food. The danger of using excessive amounts of this kind of lime fertilizer is also shown by these experiments, since if larger amounts of these valuable elements of fertility than can be used up by a crop during the growing season are rendered

soluble in the soil water, they will almost inevitably be lost from the soil by leaching.

The physical action of lime on many soils is sometimes of nearly as great importance as the various chemical effects described above. Heavy clay soils in particular are greatly improved in texture, friability, permeability to moisture, and water-holding capacity, by liming. The lime cements together the fine clay particles, forming compound particles, which are more like sand grains and give to the clay soil more of the properties of a fine silt or loam. Very sandy soils are also improved by an application of lime, which increases their water-holding capacity by its cementing action. The improvement in physical condition in very clayey and very sandy soils is frequently sufficient to warrant the use of lime fertilizers.

FORMS OF LIME WHICH MAY BE USED AS A FERTILIZER.

The term "fertilizer lime" usually means land plaster or ground gypsum. This is sulphate of lime, a neutral form having no alkaline properties. When heated to a high temperature to drive off the water which it contains it becomes "plaster of Paris" which readily takes up water again and "sets" into a very hard mass. Land plaster is the proper form of lime to use as fertilizer where its direct effect as plant food or its indirect effect in liberating potash are desired. It must be used sparingly or losses of excessive available fertility by leaching may occur. One hundred pounds per acre is as large an amount as is often safe to use. It must be applied every year, since its beneficial effects are immediate and do not extend over from season to season. It must be evenly applied, if the best results are to be obtained. This requires the use of a fertilizer spreader, since it is impossible to spread such small amounts of material evenly by hand. Implements for this purpose are described in Part II of this bulletin.

For purposes of neutralizing acid soils, improving the tex-

ture of heavy clays, etc., some alkaline form of lime is necessary. This may be either caustic or "quick" lime, slaked lime or air-slacked lime. Caustic or fresh burned lime is the most concentrated form but is difficult to distribute evenly since it is hard and lumpy and not easily ground to a fine powder. The best way to use quick lime as a fertilizer is to pile it in small heaps of say a bushel in a place, cover with a few shovelfuls of earth, then throw a pailful of water on the heap and let stand over night. The next day the lime will be slaked to a very fine powder, which can be easily distributed over the land with a shovel. The piles should be placed close enough together so as to give the desired treatment per acre. The amount of lime to be used per acre depends entirely upon the degree of acidity or other qualities which it is desired to neutralize. One to two tons per acre are quite commonly applied. The exact lime requirement of any soil can only be determined by chemical analysis. After the soil is once completely neutralized it never again needs very heavy applications of lime, fifty to one hundred pounds per acre applied about once every five years usually being sufficient. Air-slaked lime, if available, can be used instead of caustic lime for purpose of neutralization, but requires nearly twice as heavy applications to accomplish the same results, since it is partly carbonate of lime and contains only 50 to 80 per cent pure lime.

In many localities fine ground or pulverized limestone, various sea-shells, and even marl are used as top-dressings upon the soil with beneficial results. These are all carbonates of lime, marl containing also varying proportions of clay. These forms of fertilizer lime are most beneficial on light, sandy soils where they perform the functions of fine clay as well as being beneficial chemical constituents of the soil. They may be used in unlimited amounts as there are no conditions under which limestone up to several hundred tons per acre is injurious to soil or crop. On the other hand it is everywhere recognized as a valuable component of the soil.

PART II.

Farm Practices in Applying Land Plaster in Western Oregon and Western Washington.

By BYRON HUNTER.

Assistant Agriculturist, Farm Management Investigations, U. S. Dept. of Agriculture.

Land plaster is now used in Western Oregon and Western Washington, especially in the Willamette Valley, as a fertilizer for leguminous crops. It is sometimes used on vetch when grown on poor land, but its principal use is on red and alsike clover. If sown early enough to be dissolved by the rains, land plaster materially increases the yield of all leguminous crops in this section. It gives to clover a green, healthy, vigorous appearance, while untreated clover is often yellowish and sickly looking. When no plaster is used, grasses, sorrel, and other weeds have a strong tendency to crowd out the clover. Where the plaster is properly applied, on the other hand, the clover grows rapidly and holds the weeds in check much better.

Land plaster is usually applied in the early spring as soon as the ground is dry enough to be run over without being injured. Farmers who pasture their clover in the spring with sheep to retard its development so that haymaking will occur after the June rains are over almost invariably apply their plaster during March. But if plaster is applied in the early spring to clover that can not be retarded by pasturing, the crop grows

vigorously and matures for hay early in June. Rains are not infrequent at this season of the year and haymaking is often difficult. For these reasons plaster is sometimes applied the last of April or the first of May so that the crop will mature a little later.

The amount of plaster used varies from 30 to 100 pounds per acre. While some apply as high as 100 pounds per acre, farmers generally agree that from 50 to 60 is sufficient for a hay crop, provided the plaster is evenly distributed. A heavy application of plaster causes a growth of too much straw for a seed crop of clover and from 30 to 40 pounds is generally considered enough by seed growers. An application of from 30 to 40 pounds of plaster to young clover is also very beneficial. The clover starts better, makes a better stand and a heavier growth in the fall. When clover is sown in the spring with grain a heavy application of plaster causes the clover to grow too vigorously. Being shaded by the grain the stems are tall and slender. Under such conditions the hot sun may burn the clover and destroy the stand when the grain is cut. Only light applications of plaster should, therefore, be made when clover is sown with grain in the spring.

With but few exceptions land plaster is distributed by hand in Western Washington and Western Oregon. It is either distributed from a sack carried by the sower or from a box or hopper in the back end of a wagon. It is very difficult to sow plaster by hand. Too much is usually applied in the middle and not enough on the margins of each strip sown. The wind blows the plaster and it is very difficult to keep from applying it in streaks. The growth of the clover indicates just how the plaster was applied. If it is distributed evenly the growth of the crop is quite uniform over the field; but if distributed in streaks the clover also grows in streaks. Where little or no plaster falls, sorrel, grasses, and other weeds often constitute the principal part of the growth. (See Fig. 1.)

Fig. I. This figure illustrates the effect of land plaster on clover. The dark streaks on each side of the figure show the heavy growth of the clover where the plaster was applied. On the light streak in the center of the figure where no plaster was applied the growth of clover is very scant.

Sowing plaster by hand is very disagreeable. The sower breathes large quantities of the fine dust. It gets into his eyes and all over his person. Few hired men are willing to do the work and the farmer usually has to do it himself. In the attempt to get it on evenly the sower usually gets on from one and one-half to two times as much plaster as is necessary. This waste amounts to from 20 to 50 pounds per acre. Another advantage in having the plaster distributed evenly is the increase in the yield of the crop. It is safe to say that clover yields one-half ton more hay per acre where the plaster is evenly distributed than where the distribution is uneven. Again, the clover comes on vigorously all over the field and holds the weeds in check much better when the plaster is evenly distributed.

During the past season the writer made a study of farm methods of applying land plaster in the region under discussion. Farmers were found in different localities who have worked out some very satisfactory devices for this purpose. The object of this bulletin is to describe these implements that other farmers may profit by the experience of these men. It is hoped that the descriptions given herewith are sufficiently clear to enable any farmer who is reasonably handy with tools to construct, at a nominal cost, an efficient implement for distributing land plaster.

KOON'S LAND PLASTER DISTRIBUTOR.

Several years ago Mr. Clarence Koon, of Lane County, Oregon, bought a wheelbarrow grass seeder with which to sow his clover and alfalfa seed. He conceived the idea of remodeling it and converting it into an implement for distributing land plaster. He removed the seed box and replaced it with a larger and heavier box. The groove in the bottom of the box was enlarged until it was three-fourths of an inch square. The feed holes in the bottom of the groove were increased in size until they were one-half inch in diameter. A five-eighths inch feed rope was used on the box instead of the small one. With a little practice he soon learned to adjust the feed to sow any amount desired. The implement as remodeled did excellent work, but the weight of the box and plaster made it difficult to run by hand. The wheelbarrow was not strong enough to stand this extra weight so it had to be strengthened where possible. After using this device for two years Mr. Koon remodeled the box and attached it to a road cart.

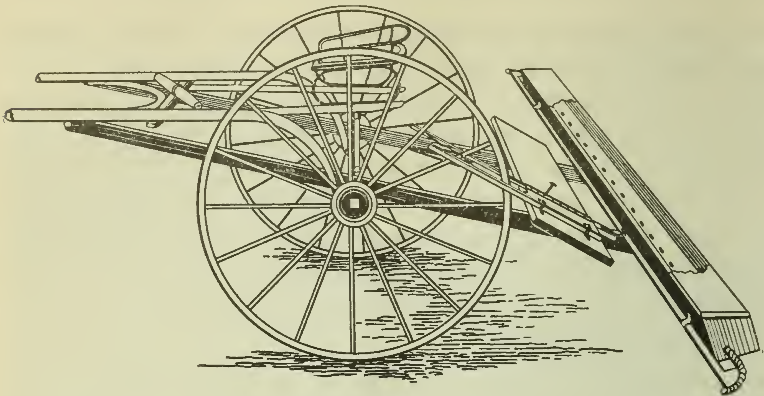


Fig. II. An implement for distributing land plaster. Devised by Mr. Clarence Koon, Lane Co., Oregon.

The box or hopper for holding the plaster is 14 feet long outside measure. The bottom board of the box is 1¼ inches thick and 6¾ inches wide. A rabbet three-fourths of an inch deep and 2¼ inches wide is cut in the upper front edge of the bottom board throughout its entire length. (See Fig. 3.) The board forming the front of the box is three-fourths of an inch thick and 5¾ inches wide. The under edge of the front board is nailed to the middle of the rabbeted edge of the bottom. This leaves a groove three-fourths of an inch square in the front of the bottom of the box, and a lip three-fourths of an inch wide on the outside upon which the bow slides. In the bottom of the groove are one-half inch holes three inches apart through which the plaster passes as it is being distributed. The groove is covered with a heavy piece of galvanized iron 2½ inches wide. On the front side of this strip of galvanized iron notches three-fourths of an inch wide and one inch long are cut. The notches are three inches apart from center to center. The piece of galvanized iron is so placed in the bottom of the box that the notches come midway between the half inch holes in the bottom of the groove.

The board forming the back of the box is three-fourths of an inch thick and 4½ inches wide. It is nailed to the back

edge of the bottom. The end boards are one inch thick, 5¼ inches long on the bottom edge, 3¼ inches wide on the back end, and five inches wide on the front end. To keep the plaster dry the box is covered with a light lid 7½ inches wide.

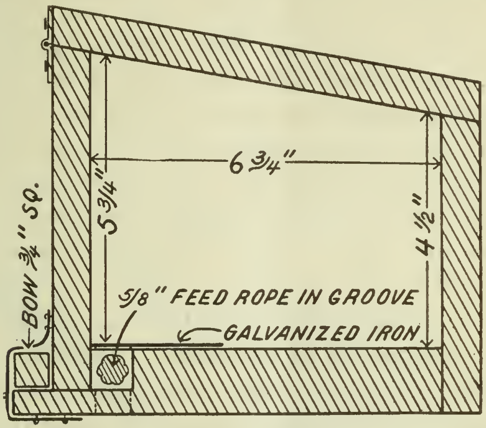


Fig. III. A cross section of the box of Koon's land plaster distributor. The box is tilted forward so that the plaster will slide to the lower front corner. Because of this position the back of the box is not as high as the front.

The bow is three-fourths of an inch thick and 15 feet long. The heads of the bow are one and seven-eighths inches wide and four inches long. The body of the bow between the heads is three-fourths of an inch square, and fourteen feet and four inches long. A five-eighths inch rope is put through the groove in the box and stretched across the heads of the bow which lies in place on the rabbeted lip of the bottom. The rope is permanently fastened to one end of the bow. The rope will stretch and it is necessary to fasten it to the other end so that it may be tightened. It may be passed round the head of the bow and tacked temporarily. A better way is to securely fasten a piece of iron with a five-eighths inch hole in one end of it across the end of the bow. The end of the iron with the hole in it projects beyond the edge of the bow enough to permit the rope to

pass through the hole. The rope is then tightened and held in place by driving a hardwood wedge into the hole beside the rope.

Fig. II shows the box attached to the cart. Scantling are bolted to the underside of the shafts. They rest on the axle and project far enough behind the cart to furnish support for the box. Wedges are placed under the back of the box to tilt it forward enough to cause the plaster to slide to the front of the box. A twelve inch board is bolted across the scantling between the box and the wheels of the cart. This is to support the lever that moves the bow back and forth. The front edge of the board is raised by means of wedges to give the lever its proper position. (See Fig. II.)

The bow is moved back and forth by means of a lever that gets its impetus from one of the wheels. The lever consists of two pieces, one being about four inches shorter than the other. The two pieces of the lever are fastened together by means of a thin flat piece of iron. The right hand margin of the iron plate is securely fastened with screws to the long piece of the lever where the latter passes over the supporting board. Half inch loops three-fourths of an inch apart pass through the iron plate, the long piece of the lever, and the supporting board. The lever is held in position on the twelve inch board upon which it rests by means of the pivotal pin, and three clamps or guide plates, two on the left side and one on the right side. These guide plates are shown in Figures IV and V. When in position they are fastened with screws to the twelve inch supporting board. The guide plate on the right is about eleven inches long. It has half inch holes three-fourths of an inch apart in its left margin through which the pivotal pin passes. The length of the stroke of the lever is controlled by changing the position of the pivotal pin in these holes. The lower left hand corner of the plate is bolted to the lower end of the short piece of the lever. In the upper left hand corner of the plate of iron is a slot an inch long. This corner of the plate of iron

is fastened to the short piece of the lever by means of a thumb screw that passes through the slot. The upper end of the two pieces of the lever each has a V-shaped iron guide attached to it with screws. Their position and shape are shown in Figures IV and V.

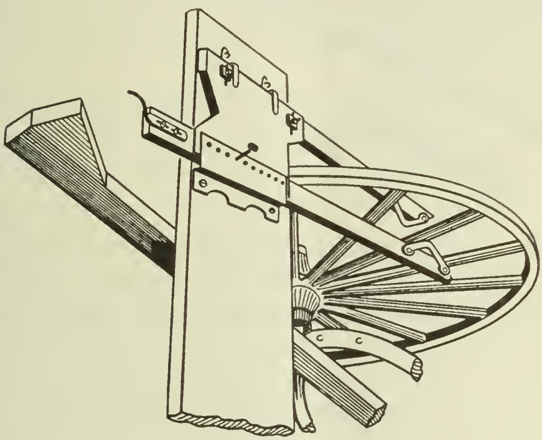


Fig. IV. The lever complete as it rests upon the board that supports it. Three guide plates and pivotal pin hold the lever in place. Two of these plates are on the left and one on the right. The one on the right has holes in its left margin through which the pivotal pin passes. On the upper ends of the two pieces of the lever are V-shaped guide plates. When the spokes strike these plates the lever moves back and forth On the lower end of the lever is an iron that catches into the staple on the bow.

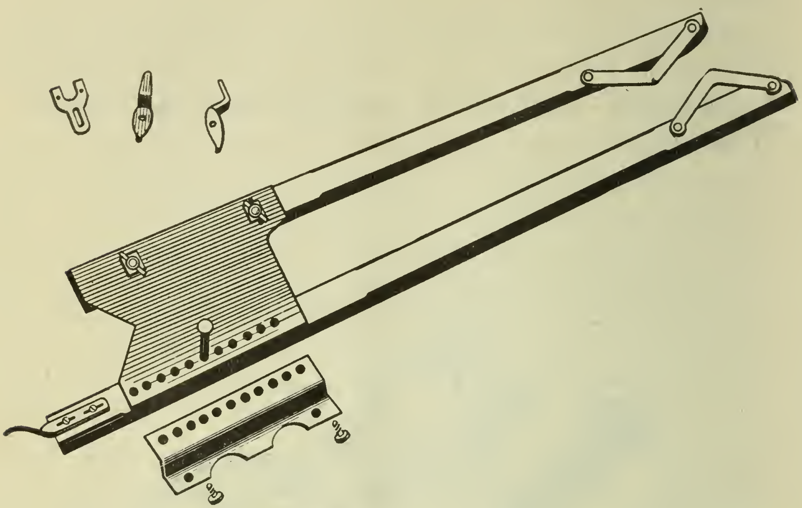


Fig. V. The lever removed and laid on a box. The clamps or guide plates lie on either side of the lever. The staple or socket into which the iron on the lower end of the lever catches is shown in the upper left hand corner of the figure. It is fastened to the bow with screws.

By means of the thumb screw just described the guide plates are set just far enough apart to allow the spokes of the wheels to pass between them. Plates of iron are fastened on the spokes where the guide plates rub to prevent the spokes from being cut off. The piece of iron that is bolted to the lower end of the lever projects far enough to catch into a socket or staple fastened to the bow. As the spokes of the wheel strike the guide plates the lever is moved back and forth. The lever in turn moves the blow. The longer the stroke the greater the amount of plaster sown and vice versa. After the rope on the bow has been used for some time it gets full of plaster and the feed is diminished slightly. A rope will sow about 100 acres. It should then be cleaned or replaced with a new one.

From the figures of this device for distributing land plaster it will be seen that it can be attached to a buggy, or the hind

wheels of the running gear of a wagon. It can also be mounted upon a pair of wheels by letting the scantling upon which the box rests extend forward far enough to serve as shafts. The wheelbarrow grass seeder is one of the best devices for sowing clover seed. A farmer who needs a plaster distributor will doubtless need a grass seeder also. We would advise those contemplating the construction of this implement first to get the wheelbarrow grass seeder. With it to look at and the descriptions given herewith its construction should be a simple matter.

In order that this implement may do perfect work the land plaster should be dry and thoroughly pulverized. Difficulty is sometimes experienced in distributing plaster that is damy and full of lumps and small pieces of uncrushed rock. Putting the plaster through a sieve to remove the lumps and pieces of uncrushed rock materially aids in its distribution.

OLSON'S LAND PLASTER DISTRIBUTOR.

Some five years ago Mr. Charles Olson, of Washington County, Oregon, undertook the task of making a satisfactory implement for distributing land plaster. During this time a local smith has constructed several of these implements and the original has been improved in several particulars.

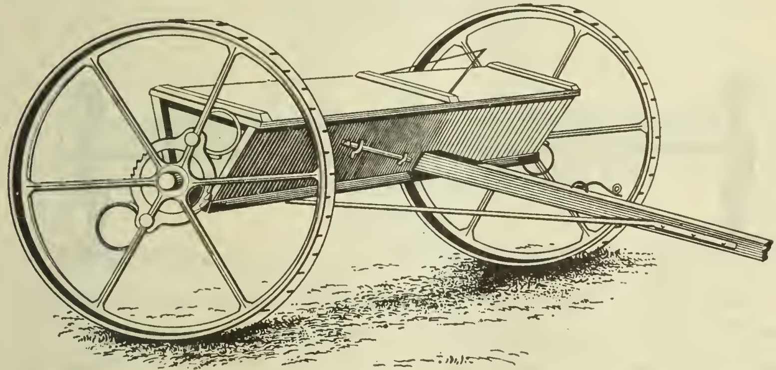


Fig. VI. An implement for distributing land plaster. Devised by Charles Olson, of Washington County, Oregon.

Figure VI illustrates a very efficient implement. It consists of a long box or hopper mounted on an old pair of mower wheels. A large square shaft revolves in the bottom of the box to agitate the plaster. The implement has a tongue and is drawn by two horses. The box is shaped very much like the box of an ordinary grain drill. It is eleven feet long but can be made any length desired. The bottom of the box is 1¾ inches thick, 5½ inches wide, and 11 feet 10 inches long, thus projecting far enough beyond the ends of the box to furnish support for the bearings. The front and back pieces of the box are 1¼ inches thick, and 11 inches wide. The lower edge of the side pieces rest upon the top of the bottom piece. The ends of the box are 1¼ inches thick. Each end consists of two pieces. The lower piece is about one inch wide and has a half-circle cut in the middle of its upper edge. When the two pieces are put together they form a circular hole through which the shaft passes. The end pieces fit the shaft snugly so that the plaster will not work out. The ends fit into grooves cut in the side pieces. They are held in place by small iron rods that run across the box. To protect the plaster during showers the box is provided with a lid thirteen inches wide.

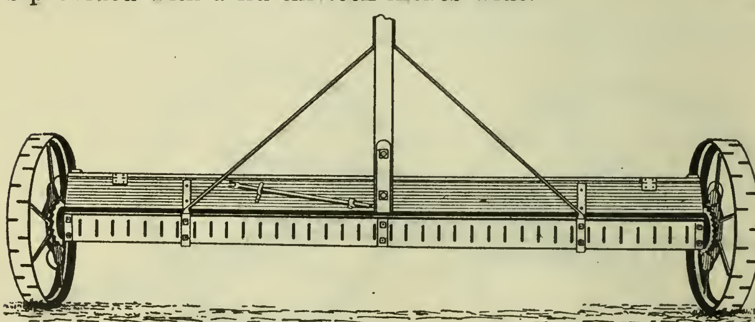


Fig. VII. This figure shows the holes in the bottom of the box through which the plaster passes and the attachment of the tongue and its braces to the box. The lever for adjusting the feed is also shown as it is carried in straps on the front of the box.

Holes for the plaster to pass through are cut in the bottom of the box. (See Figure VII.) The holes are three-eighths of an inch wide, 2¼ inches long and three inches apart. These holes run across the box, that is, the length of the holes is at right angles to the length of the box. On the underside the holes are about an inch wide. A piece of galvanized iron with holes corresponding to those just described is placed in the bottom of the box in such a way as to form a curved bottom. (See Figure VIII, which shows a cross section of the box.) This piece of galvanized iron is eight inches wide and as long as the box. Its edges are nailed to the sides. Another piece of galvanized iron ten inches wide with corresponding feed holes fits snugly over the one fastened stationary in the bottom of the box. This upper piece of iron is movable lengthwise of the box. Its edges pass up the sides of the box and are covered by cleats. The cleats are narrow strips of galvanized iron 1½ inches wide, and are nailed to the side of the box. They are bent in the middle to give room for the edges of the sheet of galvanized iron they cover. It will be seen that the upper piece of galvanized iron is only held in place by the cleats and can be moved lengthwise in either direction to open or close the feed holes.

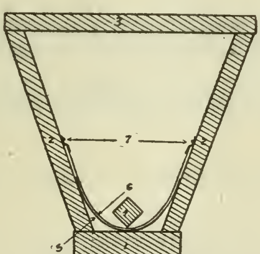


Fig. VIII. Cross section of the box of Olson's Land Plaster Distributor. 1. Botton. 2. Sides. 3. Top or lid. 4. Square shaft that revolves in the bottom of the box. 5. Stationary sheet of galvanized iron. 6. Movable sheet of galvanized iron. 7. Cleats that hold the upper sheet of galvanized iron in place.

The wheels of the implement are old mower wheels. A large iron shaft runs through the bottom of the box and connects the two wheels. On the outside of the box this shaft is cylindrical, but on the inside it is 1¼ inches square. The turning of this square rod in the bottom of the box constantly works the plaster out through the feed holes and keeps it from packing in the bottom of the box. In fact, the turning of this square shaft in the bottom of the box is one of the essential features of the implement. **It must be perfectly square and so located that the corners will just touch the** galvanized iron when it turns. Another point very essential to observe in the construction of this implement is making the holes in the two pieces of galvanized iron. **They must exactly correspond. If they do not some of the feed holes will be larger than others and the plaster will be distributed unevenly.** After the holes have been cut the two pieces of galvanized iron are riveted together, put into a vice, and the margins of the holes filed until they exactly correspond.

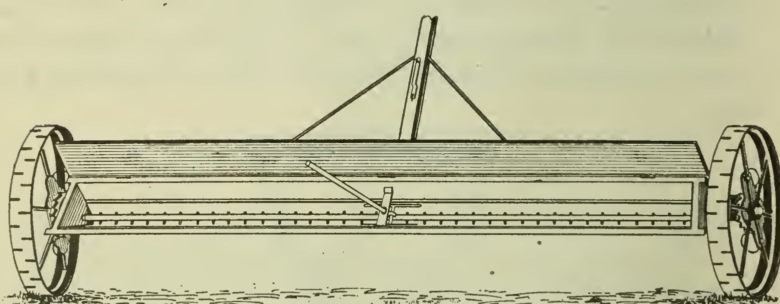


Fig. IX. A view of the inside of the box to show the feed holes, square rod that revolves in the bottom of the box, and the position of the lever when used in slipping the upper sheet of galvanized iron to open and close the feed holes.

In the middle of the box just over the large shaft that revolves a bar of iron one-half of an inch square passes across the box. The ends of this bar are split, flattened out, and

riveted to the top sheet of galvanized iron just below the cleats described above. The split ends of the bar are seven or eight inches long to give the union strength. Just over the square half-inch bar of iron just described, a flat bar of iron two inches wide with a hole in its center is bolted across the top of the box. By running a lever down through this hole and prying on the half-inch bar of iron the upper sheet of galvanized iron may be moved either way, thus opening or closing the feed holes. The lever used for this purpose is two feet long, three-eighths of an inch thick, and one inch wide. In the lower end of the lever is a half inch notch that permits the lever to slip over the half-inch bar of iron. (See Figs. VIII and IX.)

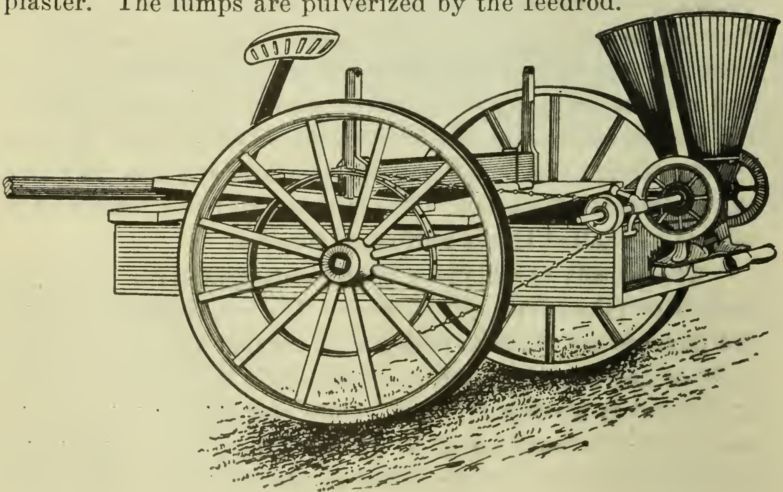
As previously stated, the bottom piece of the box projects about five inches beyond the ends. Upon these projections the bearings for the shaft are bolted. The shaft is rounded until it passes through the end of the box where it is welded to the square shaft that revolves in the bottom of the box. There is also a bearing in the center of the box. The shaft is made cylindrical for about two inches at its center. A broad staple is driven down over the shaft. The staple passes through the bottom and an iron plate that is fastened to the tongue. It is fastened below with nuts. This center bearing is necessary to take the shake out of the shaft and hold it in place so that it will rub the bottom just right. In addition to being bolted to the bottom the tongue has iron braces on either side. To keep the box from spreading there are two iron stirrups that fit on the underside of the box. The stirrups and side braces of the tongue are bolted to the bottom of the box.

The wheels of all these implements that have been made have been taken from old mowers. The wheels best suited for the purpose are those provided with ratchet wheels into which palls or catches drop and cause the shaft to revolve when the implement is moving forward. Only one ratchet wheel is necessary if the implement is driven around the field to be plastered with the ratchet wheel on the outside. Some means

should be provided for raising the catches that drop into the ratchet wheels so that the shaft will not revolve when going to and from the field. Otherwise it will be necessary to close the feed holes. If wheels with ratchets are not to be had a hole may be drilled through the shaft and the hub of one of the wheels. The shaft will be revolved by putting a pin through this hole. The implement should then be driven around the field with this wheel on the outside, so that the plaster will be sown when turning the corners. When taking the implement from one place to another the pin in the end of the hub can be removed. With the pin out the shaft will not turn, and little or no plaster will be sown. This is a very efficient implement. Its construction costs from $35 to $40. The help of a smith is necessary.

This is a very efficient implement and so far as the writer knows, only fails to work when the plaster is very damp. When the plaster is in this condition it sticks to the feedrod and does not go through evenly. Under these conditions it is necessary to spread the plaster in the sun to dry.

With this machine it is not necessary to screen lumpy plaster. The lumps are pulverized by the feedrod.



ENDGATE SEEDERS.

A number of farmers are using endgate seeders for sowing land plaster. This seeder is easily attached to a wagon, the board to which it is bolted being the same width and length as the endgate of the wagon box. If the plaster is dry and the air still they do fairly good work. If the plaster is damp it gives some trouble by packing in the feed hopper. The machine being so high above the ground it is difficult to do a good job when the wind is strong. It is best to drive at right angles to the direction in which the wind is blowing. The worker can then keep himself reasonably free from the dust.

Most of the endgate seeders used for sowing land plaster have but one fan. Mr. C. R. Widmer, of Benton County, Oregon, uses a double fan machine with a clover seeder attachment. The seeder is attached to a cart made from the hind wheels of an old wagon. The coupling is replaced by a pole that serves as a tongue. The side pieces of the box are two inches thick, twelve inches wide, and six feet long. The box projects behind the axle 2½ feet. It is swung under the axle by means of iron stirrups. The front end of the side pieces of the box are bolted to a two inch by six inch scantling that crosses the hounds. A bottom is placed in that portion of the box behind the axle. On the front part of the cart is a seat for the driver. The board to which the seeder is attached forms the endgate of the box. When the seeder is mounted on a cart in this way the fans that throw the plaster are just eighteen inches above the ground, and the effect of the wind on the plaster is much less than when the machine is attached to a wagon box. This double-fan seeder has a force feed and little trouble is experienced with clogging unless the plaster is damp. When it clogs a light tap on the hopper usually starts the feed again. The machine has two hoppers, one for grain and the other for clover seed. The plaster is sown from the clover seed hopper. About thirty-five pounds of plaster can be placed in the hopper at a time. The machine mounted on a cart as

described sows a strip ten feet wide. A marker at the side of the cart indicates the next place to drive. All of these implements do better work if the plaster is put through a sieve to take out the small pieces of uncrushed rock.

ADVANTAGE IN DISTRIBUTING THE PLASTER EVENLY.

There are several reasons why every farmer in Western Oregon and Western Washington who uses land plaster should provide himself with a satisfactory way of distributing it.

1. It is very difficult to distribute land plaster evenly by hand. Parts of the field will receive too much plaster and parts will not receive enough. Where there is too much plaster the growth may be so rank that the clover falls before it can be harvested. Where there is not enough plaster the growth is seldom what it should be. It is a conservative estimate to say that clover will yield one-half ton more hay per acre when the plaster is evenly applied than when the distribution is uneven.

2. Most men apply more plaster than is necessary when sowing it by hand. An implement that distributes it evenly will usually save from twenty to fifty pounds per acre.

3. Where the plaster is evenly distributed the crop comes on vigorously and quite evenly all over the field, and holds the weeds in check. Sorrel, grasses, and other weeds usually give considerable trouble in clover and alfalfa where no plaster is used, or where the distribution is uneven.

4. Sowing plaster by hand is an unpleasant task. Men are scarce who can apply it evenly and few hired men can be trusted to do it. For these reasons the farmer usually has to do it himself. A good implement for distributing the plaster makes it possible for any one to do the work who can drive a team.

State College of Washington

Agricultural Experiment Station

PULLMAN, WASHINGTON

DEPARTMENT OF CHEMISTRY

THE HYBRID WHEATS

By W. J. Spillman

BULLETIN No. 89

1909

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Introductory Note.

The following bulletin was prepared at my request by W. J. Spillman, who was formerly Agriculturist of this Station but is now in charge of the Farm Management Investigations of the Bureau of Plant Industry of the United States Department of Agriculture. It contains a history of the inception, progress, and results up to the present time of the investigation at this Station of the possibility of the production of new varieties of wheat having certain desirable characteristics by means of crossing or hybridizing existing varieties. During the early progress of the investigation certain laws of breeding which are of highest importance to scientific and practical plant breeders have been discovered, others which had been known but had received little practical consideration have been confirmed and strikingly illustrated in practical field work. The original object of investigation, namely, the production of a hardy winter wheat with stiff straw and close chaff, has been successfully attained, and several of the new hybrid wheats are now being grown with remarkable success over large areas in this and adjoining states. A brief popular description of the more important characteristics of these has been published in Popular Bulletin No. 9, of this Station.

The original plan of the work was conceived by Prof. Spillman and the earlier crosses and selections were made by him personally or under his supervision. Following his departure from this institution the work of selection, propagation, and field trials of the original hybrids, together with the production of many new crosses, has been carried on by several new members of the Agricultural Department of the Station. Professor

Spillman's interest in the work and its outcome has continued unabated and he is, therefore, particularly well qualified to present as he has done in this bulletin a concise report of the work thus far completed.

The investigations in this direction are by no means completed. New crosses and new combinations of desirable characters are continually being sought. Some of the hybrids from the first crossings are being reinforced in certain desirable characters by re-hybridizing upon one or the other parent variety. Many very promising new hybrids are now ready for field trial or are fixed. Bulletins giving the results of this further work will be issued from time to time. The strikingly successful outcome of some of the original crosses made by Professor Spillman makes this history of the work on these up to the present time written by him peculiarly appropriate.

R. W. THATCHER, Director.

The Hybrid Wheats.

BY W. J. SPILLMAN.

When the writer assumed the responsibilities of Professor of Agriculture in the Washington State College and Agriculturist to the Washington Experiment Station, July 1, 1894, the price of wheat at Pullman was about 18 cents per bushel. The year before most of the wheat growers of Eastern Washington had lost their crop by untimely rains. In 1895 the price of wheat rose to about 25 cents a bushel. There was thus a period of three years when the farmer either lost his crop of wheat or could not sell it for what it had cost him. The one great problem of agriculture in Eastern Washington therefore seemed to be diversification. While it was recognized that Eastern Washington was one of the great wheat regions of the world, the lesson had been made very plain that any system of agriculture is very unsafe when it is based on a single crop. The first great problem the solution of which was attempted was that of finding suitable grasses as a basis for live stock farming. When the problem of hay and pasture crops had been partially solved, attention was turned to problems relating directly to wheat growing, as it was evident that wheat would continue to be the principal money crop of the average farmer. A circular letter was sent to a large number of farmers in the wheat growing sections of the state asking for various kinds of information. One of these questions was: "What variety of wheat do you grow, and why do you grow it?" When the answers to these questions were tabulated the following interesting fact was developed. In those portions of Eastern

Washington where the rainfall is greater than 20 inches a large majority of the farmers reported that they grew Little Club, and stated as their reason that it would stand up better than Red Chaff and hold its grain better. Several other varieties of wheat were mentioned from this belt, but no one variety from many farmers.

In those sections where rainfall was about 18 inches, a large majority of the farmers reported that they grew Red Chaff, stating that it stood up better than Blue Stem and yielded better than the Little Club. Few other varieties of wheat were mentioned in the Red Chaff region.

Where the rainfall was less than 17 inches a large majority of those who answered the letter stated that they grew Blue Stem, as it was the only variety of wheat they had found which grew tall enough in their dry section. They further stated that they preferred Blue Stem because it sold at a higher price than Red Chaff.

It is to be noted that very few correspondents who lived in the Little Club region mentioned Blue Stem in any way. Likewise, those who lived in the Blue Stem region seldom mentioned Little Club. But most invariably those who grew Red Chaff mentioned both Little Club and Blue Stem.

The last question in the circular letter referred to above was: "What can the State Experiment Station do for the wheat growers of the state?" Singularly enough, every one who answered the letter gave the same answer to this question, varying the answer only as it related to the variety which the farmer grew. For instance, from the Little Club belt the answer was: "Give us a winter wheat as well adapted to this section as Little Club." The answers from the other two sections were the same except that they mentioned Red Chaff and Blue Stem respectively.

It seems that since the earliest settlement of Eastern Washington farmers have been experimenting with varieties of wheat, and the three varieties above mentioned were the only ones which at that time had been found to be generally adapted to the regions in question. This statement applies particularly

to that portion of the wheat region which lies east of the dry region in the central part of the state. It happens that the three varieties, Little Club, Red Chaff, and Blue Stem, are all spring wheats but they were generally sown in the fall because of the larger yield obtained from fall sowing. Unfortunately, however, when a hard winter occurred these spring varieties were badly killed out and frequently had to be resown in the spring. There was, therefore, an urgent demand for a wheat that was hardy enough to stand the winter.

The answers to the circular letter made it clear that the one large problem of the wheat grower was to find a satisfactory winter wheat. Fortunately, the State Experiment Station had already made a collection of winter wheats from various sources, and for five years these wheats were carefully tested with a view to finding which of them were best suited to local conditions. The fact developed, in these tests, that all the winter wheats which had been obtained had two serious faults. In the first place, the straw was weak and a wind storm occurring after the wheats had reached the heading stage would blow them down. Furthermore, when ripe the chaff stood partially open so that the grain easily shattered out. This was more or less the case with every variety of winter wheat tested. Yet, a good many of the varieties produced enormous yields when the season was favorable and when they were harvested promptly after ripening.

Since it appeared to be impossible to find suitable varieties of winter wheat, in the season of 1899 it was decided to attempt to produce new varieties by crossing the best of the winter wheats with the best springs wheats that could be grown at Pullman. The first step was to examine all the available literature in order to ascertain what would be the best method of procedure and what chance of success there might be from this type of work. About the only information of value that could be had from the books at that time was this: if we cross two varieties of wheat and get, say, a hundred grains of hybrid wheat, all of the same breeding, the next year these hundred grains will make plants fully as similar to each other as an or-

dinary variety of wheat. Furthermore, the books stated that when the seed from these hybrids was saved and planted the next year there would be enormous variability and that a very large number of kinds of wheat would appear in the second generation of the hybrid. This seemed encouraging, and it was hoped that in the second generation amongst the numerous types to be expected we might find some good winter wheat adapted to the section. There was also an idea in the writer's mind that it might be possible to combine the good characters of the varieties which were crossed.

There was one other doctrine found in the books then available to the effect that when a given type of wheat is found in the progeny of a hybrid, if that type were selected year after year the amount of it in the mixture would gradually increase, and that in from six to eight years any of the types could be made practically fixed like an ordinary variety of wheat. We now know that this is true of certain types which occur in the second generation of a hybrid and untrue of other types. This will be made clear later.

For producing the hybrids either Little Club or Red Chaff was used in every cross made. Eleven of the best yielding of the winter varieties on hand were chosen for crossing with Little Club or Red Chaff. In three instances the crossing was done both ways—that is, pollen from a spring variety was put on the stigmas of a winter variety so that the hybrid seed grew on the winter variety, and, vice versa, pollen was taken from the winter variety and transferred to the spring variety so that hybrid seed grew on the spring variety. In each of these reciprocal crosses the results were exactly the same whichever parent grew the seed.

The work of crossing two varieties of wheat is not an easy task. The principles involved are shown in Figure 1. In the

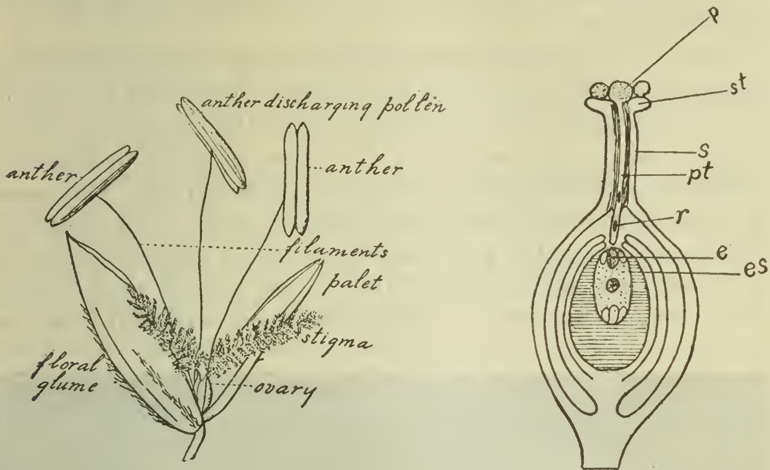


Figure 1

Showing principles involved in hybridizing wheats. On the left—parts of a single floret. On the right—showing action of pollen.

left hand part of the figure is shown a single flower of the wheat plant. The part marked "ovary" is that which develops into the grain after it has been fertilized by the pollen. The anthers, three of which are seen in the upper part of the flower contain the pollen. Down in the ovary is a certain vegetable cell which contains only half of a nucleus and which therefore cannot grow in that condition. The pollen grains likewise contain only half of a nucleus. What happens when the pollen grains fall on the stigma is shown in the right hand portion of Figure 1, which shows a different form of stigma but in which identically the same thing occurs as in wheat. The pollen grain (p), when it lights on the stigma, sends out a little root-like thread which grows down through the tissues of the style (s), just like a little rootlet growing down into the soil. At the tip of this pollen tube is found a half nucleus, marked "r" in the figure. When the pollen tube reaches the

ovule (o), the half nucleus from the pollen tube unites with the half nucleus of the ovule, and then growth begins and the seed is formed.

Now in the wheat plant, ordinarily the pollen which fertilizes the ovule is produced in the same flower with it. In order to hybridize two varieties of wheat, therefore, it is necessary to cut out the anthers of the flower in order to keep the pollen from fertilizing the ovule in the same flower. This must be done before the flowers are ready to open. The matter is considerably simplified by cutting off every alternate mesh of the head and cutting out all the flowers in each mesh except two. (Figure 2.) Then all the anthers are extracted from the

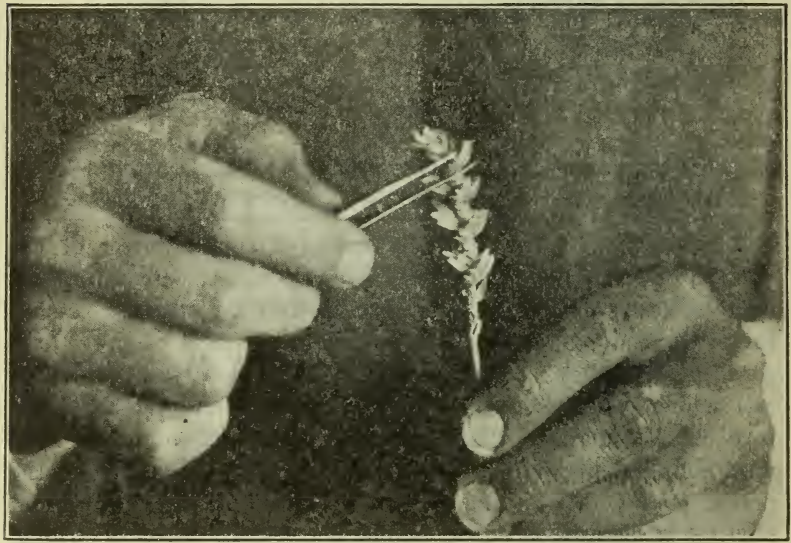


Figure 2
Preparing a Wheat Head for Hybridization.

flowers left on the head, and the head is covered with a paper sack to keep foreign pollen from getting in and fertilizing the ovules. At the proper time pollen is secured from the other variety to be used in the cross, the paper sack is removed tem-

porarily, and the pollen dusted on the stigmas. Then the paper sack is put on again to prevent the chance of other pollen getting in before the pollen which has been put on the stigma has had time to act. If the work has been carefully done the seed produced as a result of this operation will be hybrid between the two varieties.

This work was planned by the writer and the preparation of the heads for hybridizing was done by the writer and Mr. H. F. Blanchard, who was at that time a student in the college. But before time came for transferring the pollen over-work had made it necessary for the writer to discontinue all work for a short period, and the transferring of the pollen was done by Professor E. E. Elliott, at that time connected with the Experiment station.

About a thousand flowers were treated, but only 303 of them produced grains. The manipulation of the young flowers had caused many of them to fail to set seed. Perhaps, in some cases, the pollen was not put on at exactly the right time. Nearly half of the seed proved not to be hybrid. Evidently, the anthers were removed too late and pollen had already fallen on the stigmas, or did so while the work was in progress. All the seeds obtained were planted, each seed being put six inches from its neighbors with a stake beside it containing a number which enabled us to refer to the records showing the breeding of each of these grains. During the winter a hard rain storm made a gully through the little plat where these hybrids were planted and washed out about one-fourth of them. As already stated, a considerable number proved not to be hybrids but 149 hybrid plants matured seeds. These were of eleven different types, as follows:

Pollen Parent	Seed Parent	No. of Hybrids Secured.
Jones' Winter Fife	Little Club	22
White Track	Little Club	4
Turkey	Little Club	7
Emporium	Little Club	2
Little Club	Emporium	6

Pollen Parent	Seed Parent	No. of Hybrids Secured
Farquahar	Little Club	7
Little Club	Farquahar	27
Valley	Little Club	3
Little Club	Valley	11
White Track	Red Chaff	2
McPherson	Red Chaff	6
Jones' Winter Fife	Red Chaff	7
Farquhar	Red Chaff	1
Lehigh	Red Chaff	3

The total number of hybrids given here is only 108. This represents the number that were preserved beyond the second generation. The remaining 41 were sorted into types in the second generation by inexperienced persons, whose work had to be discarded.

All the hybrid plant made remarkably fine heads of wheat, and it was found that what the books had said about the similarity of hybrids of similar breeding was true. For instance, the 22 hybrids produced between Jones' Winter Fife and Little Club were much alike as a similar number of plants in any ordinary variety of wheat. In every case the hybrid had more or less of the Club character, but the heads were generally longer and had more grain in them than Little Club. On the other hand, all of these 22 hybrids had the velvet chaff character of Jones' Winter Fife. It was expected that the next year each of these hybrids would break up into a large number of types and that one of the types would be just like the hybrid, and this actually occurred. We further expected that by selecting each year the type like the original hybrid and planting its seed separately in a few years the type could be fixed. As will be seen later, it is impossible to fix the type of the original hybrid.

At harvest time each of the hybrid plants was harvested separately. One head from each plant was removed and saved for future reference; the other heads were threshed out by

hand, and the one head saved and all the grain threshed from a single plant were put together in an envelope and properly labeled.

In the fall of the same year (1900) a single row of wheat was planted from the seed in each of these envelopes, and in each case seed of similar breeding was planted side by side. Thus, there were 22 rows of one kind, each row representing the progeny of a single plant of the year before. Then came 11 rows of another kind, and so on through the whole series. Each row this second year represented the progeny of a single hybrid seed of two years before.

When these wheats began to head out the second year, there was at first an apparent confirmation of what the books had said. In every row there were several very distinct kinds of wheat, and first I got the impression that we had nearly every kind of wheat imaginable in each of the rows, and I looked forward with some misgiving to the tremendous task of picking out of this immense number of kinds the particular varieties wanted. In the first rows that headed out a brief examination of one of the rows revealed 19 distinct types of wheat, and it was found later that there were actually 24 distinguishable types in that row. A great deal of time was spent studying these wheats while they were heading out.

Discovery of the Law of Recombination

These hybrids were grown on the hillside just north of the college barn. One day, after the wheat had headed out, the writer was standing on the top of the hill above the plats looking down at them. He noticed that in the 22 rows near the southwest corner of the grounds there were no bearded heads, while in the next 11 rows there were some bearded heads in every row. Instantly the thought occurred that we did not simply have great variability, but that in each row we simply had new combinations of the characters of the original parents. Examination was made of every row of the hybrids at once, and in every case it was found that what was present was simply recombinations of the original parent characters, and nothing else. Along with the recognition of this fact came the

suggestion that if there is a law requiring each possible combination of the original parent characters to occur in the second generation of a hybrid, that this law would require each of these combinations to occur in a definite proportion in each row. This point could not be determined until the wheats were ripe, but as soon as they were ripe enough the plants in each row were pulled and then separated into the different kinds present. Figure 3 illustrates the result. At the top of

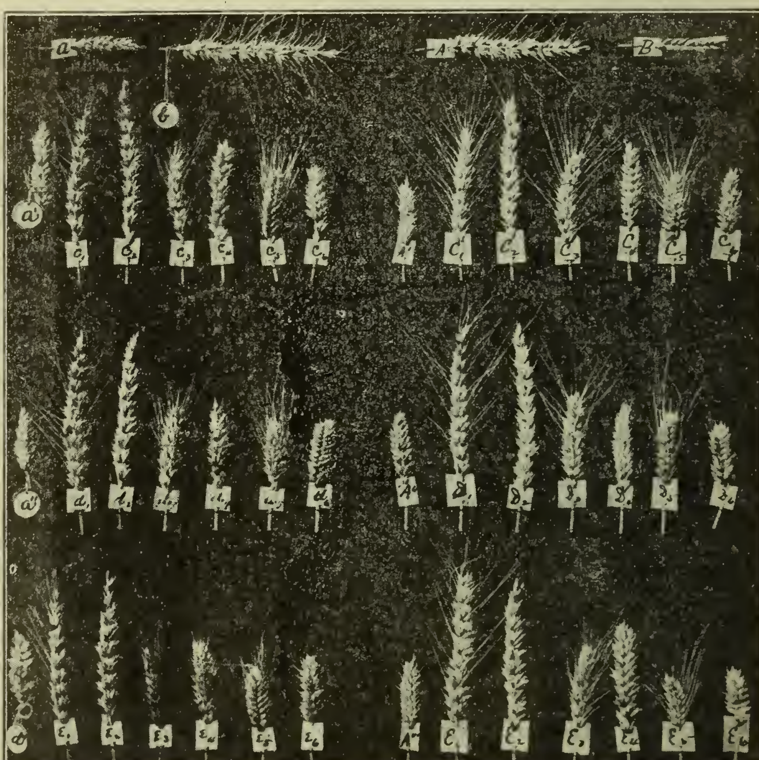


Figure 3

First and second generations of the hybrid between Valley and Little Club. In the left half—Little Club pollen was placed on Valley stigmas; in right half the reverse cross was made A', A'', A''', a' a'', a'''. All first generation hybrids. To the right of each is shown its progeny.

the figure is shown the parents of the cross, namely, Little Club and Valley. In the left half of the figure are shown the results of using Little Club pollen on Valley stigmas; the right half of the figure shows the reverse cross—that is, Valley pollen on Little Club heads.

As previously stated, eleven hybrids were grown, representing the cross of Little Club on Valley. Three others representing the opposite cross were grown. Three first generation hybrids of each of these crosses are shown in Figure 3, three at the extreme left, and three in the middle of the figure to the right of the space between the right and left halves. It is seen that each of these six heads is very similar to Little Club, but that most of them have a very slight tendency to be bearded. The second generation is shown to the right of each of the six first generation plants. Take, for instance, the upper right hand portion of the figure; the plant marked "A*" is a first generation hybrid. The six plants to the right of it, marked C1-C6, were all grown from the seed of one plant marked "A*." Similarly, the six plants to the right of each of the first generation hybrids grew from the seed of the first generation hybrid at the left of each group. It is seen that in the case of each of the six first generation hybrids the second generation consists of the same six types of wheat. In each case there are two long heads, one bearded, and the other smooth; two club heads, one bearded and the other smooth; and two heads of intermediate length, one bearded, the other smooth.

Furthermore, the long bearded head at the left of each group of six constituted about 6 per cent of the row in which it grew. That is, 6 per cent of the row had long bearded heads like those sown. The long smooth head in each case constituted about 18 per cent of each row, and so on for each of the other types.

We may now state the law of recombination, which is as follows: In the second generation of a hybrid there tends to occur every possible combination of the original parent characters and every possible hybrid between these combinations.

The first part of this law was enunciated by the writer in an article read before the Association of American Agricultural College and Experiment tations in November, 1901, which was published in Bulletin 115 of the Office of Experiment Stations of the United States Department of Agriculture.

As soon as this law was recognized in the hybrid wheats it was clear that in each of the crosses made we had obtained what we had planned for, namely, some plants in which we had combined the winter hardiness of the winter types, the stiff straw of the Club type, and the tightly closed chaff of the Club type, and subsequently this was found to be the case.

The law of recombination is so important that it deserves further illustration. Figure 4 shows all the combinations that can be made of the winter and spring character, weak and stiff straw, open and closed chaff. When we cross a winter and a spring wheat, in the second generation of the hybrid one-fourth of the progeny is pure winter wheat, one-fourth of it pure spring wheat, the remaining half of it is hybrid between spring and winter wheat, as shown in Fig. 1. Then if the parent winter wheat has weak stems and the parent spring wheat stiff stems, each of the three groups mentioned above is subdivided further into three groups, one-fourth of each being pure weak stem, one-fourth pure stiff stem, the remaining half hybrid between weak and stiff stem. This gives us nine types based on the winter and spring character and on the stiffness of the straw. Then with each of these nine types we may have pure open chaff, pure closed chaff, and the hybrid between the two, thus making in all 27 types that occur in the second generation. Of course, if the parents differ in other respects these types will be further subdivided.

It will be noticed that in Figure 4 eight of the types are marked with a cross mark after them. These eight types are all pure with reference to all three of the characters concerned —that is, they are not hybrid with any reference to any of these characters, and this means that they will reproduce true to type and require no further selection to fix up their type. The one type which was sought in this work is marked, in Figure 4,

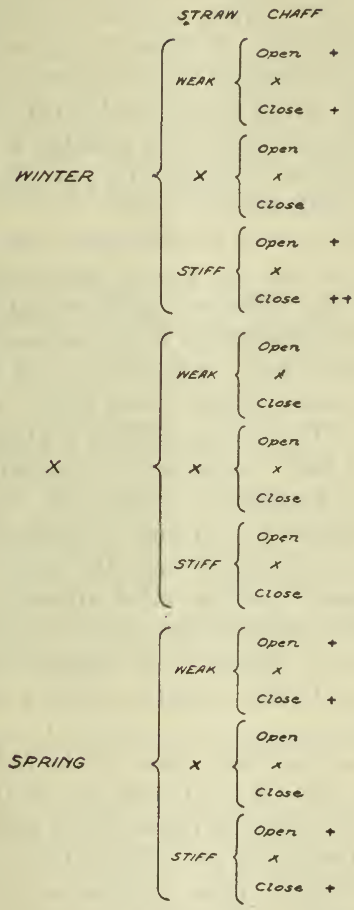


Figure 4

Diagram illustrating second generation of the hybrid between a winter wheat with a weak straw and open chaff and a spring wheat with stiff straw and closed chaff. Illustrates law of recombination.

with two cross marks. It has the pure winter character, pure stiff straw, and pure closed chaff.

Unfortunately, it is not always possible to tell the hybrid from one of the pure types, so that generally speaking it is necessary to plant many of these 27 types again, saving the seed from each plant separately, in order to see from the next generation which of the plants are hybrid and which are not. But by the third generation it is possible to pick out any desired pure combination in a perfectly pure form that will thereafter reproduce itself true to seed.

At the time this law of recombination was discovered it was not recognized that in the second generation every possible hybrid between the different forms would also occur along with the various combinations in the second generation. This fact and the reason for it were discovered by others shortly before the work here reported was done. In 1899 Professor Hugo De Vries, of Holland, published a little pamphlet giving this discovery in full. Immediately thereafter Professor William Bateson, of England, Professor E. Von Tschermak, of Austria, and Professor C. Correns, of Germany, published data showing that they had discovered the same laws, and at the same time Professor Correns called attention to the fact that these laws had been worked out in very complete form and published in 1865 by a priest in an Austrian monastery. This priest's name was Gregor Mendel, and the law is now known as Mendel's law.

Mention has already been made of the fact that it is not always possible to tell a hybrid from one of the pure forms related to it. For instance, in Figure 3 the three heads of wheat shown at the extreme left are hybrids between the two shown at the top of the figure. These hybrids have the Club character of one of the parents. They also have the long head character of the other parent, but it does not show. It does show, however, in their progeny. Furthermore, one of the parents is bearded and the other smooth. The hybrids are either not at all bearded or very slightly so. Mendel expressed this by saying that when two opposite characters meet in the same individual

one of these characters usually dominates the other and only one of them shows. The one which does show is called the dominant character, the other is the recessive character. This fact is usually referred to as the "law of dominance." We have many illustrations of it. Ordinarily when we cross a white breed of hogs with a black breed the pigs are all white. Thus, the white is dominant and black is recessive in this cross. Similarly, when we cross a pure polled animal with a horned breed the calves are all polled, or at least have only scurs, and hence we say that in cattle the poll character is dominant and horns recessive.

But this relation between two opposite characters does not always hold. For instance, there are two breeds of Andalusian fowls, one of which is black and the other white with black splashes on the feathers. We will refer to the latter breed simply as the white Andalusian. If we cross these two breeds the hybrid is neither black nor white but blue, and this is always the case. In this cross we do not have the phenomenon of dominance. If we mate these blue Andalusians together, in the next generation one-fourth of the chicks are pure black, one-fourth of them are pure white (with black splashes), the remaining half are blue—that is, they are hybrids between the white and the black, as called for by the law of recombination.

Cause of the Law of Recombination

The reason why we find in the second generation of a hybrid every possible combination of the characters of the original parent of the hybrid is seen in what follows. The bodies of plants and animals are made up of small particles called cells. These cells are very complex in their internal structure and contain a number of small organs which are believed in some way to be responsible for the hereditary characters. Growth takes place by the enlargement of the cells, and when a cell in a young growing animal reaches full size it divides into

two cells. This is shown in Figure 5. The left hand part of the figure, under the word "somatic," shows the manner in which this ordinary cell division occurs. Figure 5 shows the

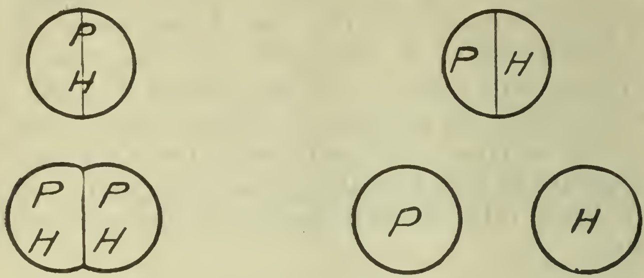


Figure 5

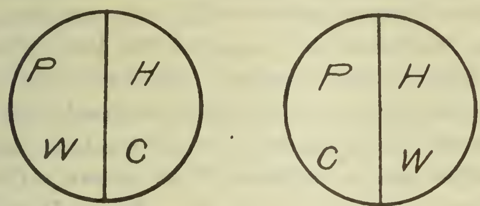
Illustrating cell division. Ordinary division of body cell at left; at right, type of division when cells are produced.

cells of an animal which is a hybrid between a polled and a horned breed. When a cell divides the little organs which represent the two hereditary characters in question line up in the middle of the cell and divide as the cell divides, giving two new cells each of which is provided with the two characters. Thus, presumably, every cell in the body of such a hybrid has in it the basis for both the poll character and the horn character. But when reproductive cells are produced the cell division occurs in a different way, as shown in the right hand portion of Figure 5. The two organs representing the two characters line up side by side and the cell division occurs between them, so that two kinds of reproductive cells are produced, one bearing the poll character, the other the horn character.

Figure 6 shows the method of producing reproductive cells in a hybrid between the Polled Durham, which has a polled head and a colored face, and the Hereford, which has horns and a whit face. Here we have two pairs of opposed characters, one pair consisting of P and H, the other of white (W) and colored face (C.) These two pairs of characters line up at the time when reproductive cells are produced, and each pair is

LAW OF RECOMBINATION.

GERM CELLS OF HYBRID.



PROGENY OF HYBRID.

	PW	HC	PC	HW
PW	PPWW	PhWc	PPWc	PhWW
HC	PhWc	HHCC	PhCC	HHWc
PC	PPWc	PhCC	PPCC	PhWc
HW	PhWW	HHWc	PhWc	HHWW

1. PP WW   2. Ph WW   1. HH WW
2. PP Wc   4. Ph Wc   2. HH WC
1. PP cc   2. Ph CC   1. HH CC

Figure 6
Explanation of law of recombination. See text.

separated by the division. But the two pairs are independent of each other and may stand as shown at the left or as shown at the right in the upper part of Figure 6. This gives us four possible kinds of reproductive cells, one containing the poll character and the white face, another the horn character and and colored face, a third the poll character and the colored face, while the fourth contains the horn character and the white face. Now each sex produces all four kinds of reproductive cells. Below the circles in Figure 6 are shown all the uossible unions of these cells, sixteen in all. When P and H occur together the H is written small because the horn character is recessive. Likewise, when W and C occur together the C is written small because white face is dominant and colored face recessive. It will be noticed that some of the sixteen types are alike. At the bottom of Fig. 6 are shown the different types which do occur and the proportion in which they occur. Thus, in a cross where the parents differ in respect of two pairs of characters, in the second generation there are nine types of progeny. It will be noticed that of the nine types shown in the lower part of Figure 6, four of them are pure with reference to all the characters that occur in them, while the remaining five are hybrid with reference to one or both of the character pairs.

The writer claims only to have discovered the fact that in the second generation of a hybrid every possible combination of the original parent character occurs. He did not discover the law of dominance or the fact that in the second generation, in addition to all the possible combinations of parent characters, there also occurs every possible hybrid between these combinations. Mendel was the first to discover all these things, including the law of recombination.

Field Tests of Hybrid Wheats

The work of selecting out fixed types of these hybrids (it must be understood that there are many types secured from each of the original hybrids) and of propagating sufficient seed of them to give them field trial occupied the years 1902, 1903, and 1904. Meanwhile, many other hybrids were produced. The

writer severed his connection with the Washington State Experiment station to take up ihs work with the United States Department of Agriculture January 1, 1902. Since that time the work with these hybrid wheats has been carried on by his successor, Prof. E. E. Elliott, and his assistants, especially Mr. Jno. Evans and Mr. C. W. Lawrence. The work of picking out the fixed types and of testing them to ascertain which were most worthy of distribution amongst the farmers of the state has been done mostly by Mr. Lawrence, under the direction of Prof. Elliott.

In 1905 field tests for yield began. The following data concerning these tests have been kindly furnished the writer by Mr. C. W. Lawrence of the Washington State Experiment Station, who now has charge of the work with these hybrid wheats. Part of the data has already been published in Popular Bulletin No. 9 of the Washington Agricultural Experiment Station (August, 1908). It is thought proper to re-publish it here in order to bring the facts regarding these hybrid wheats together for convenience and reference.

Hybrid	Crop of 1905	Crop of 1906	Crop of 1907	Crop of 1908	Average
	White Track X Little Club				
143 A*	30	58	53	38	44.75
143 B				51.50	51.50
	Turkey X Little Club				
60			31-32	49.50	37.50
61 A	35.50	56	40-50	36	42
61 B				52.50	52.50
63 A	36.50	60	41.50	36.50	43.62
63 B			30.31	52.50	40.72
150	36.50	60	42.00	36.50	43.75
	Winter Fife X Little Club				
67	37	65	52	38.50	48
108 A	36.50	60	52	37	46.37
108 B			30-33	54	42.69
123	36.50	60	51	36	46.62

Hybrid	White Track X Little Club				
	Crop of 1905	Crop of 1906	Crop of 1907	Crop of 1908	Average
128	37	60	53	37	46.75
219 A	33.50	57	49	35.50	43.75
219 B			29.30	52.50	37.16
Red Russian A	29	58	46.50	33.50	41.75
Red Russian B	28.50	53	37.50	50.50	42.37
Little Club A		59	45.50	34.50	r43.33
Little Club B		52	38.50	48	r46.16

*Letters following the same number indicate different strains selected from the same original stock except in the case of Little Club; A and B here simply represent duplicate plats of this variety.

rThis average is too high, as it does not include the low yields of 1905.

It will be seen by comparing the last four lines of this table for the years 1906, 1907, and 1908, that Red Russian and Little Club yield about the same. Furthermore, the average yields for Little Club in the right hand column do not contain the low yields of 1905, and are hence too high. Taking 42 bushels as the average yield of Red Russian for the four years, every one of the hybrids, except 219 B, 63 B, 61 A and 60 B, has outyielded Red Russian on the average of the four years.

The excess of yield of the hybrids over Red Russian is as follows:

No. 143 A	2.75	bushels
No. 143 B	9.5	bushels
No. 61 B	10.5	bushels
No. 63 A	1.6	bushels
No. 150	1.75	bushels
No. 67	6	bushels
No. 108 A	4.37	bushels
No. 108 B	.69	bushels
No. 123	4.6	bushels
No. 128	4.75	bushels
No. 219 A	1.75	bushels

It must be remembered that the main object sought in this work was to secure hardy winter strains that had stiff straw and tightly closed chaff. Even if the hybrids yield no more in a favorable season than Red Russian or the ordinary Little Club, if they have winter hardiness they possess an enormous advantage. It is seen, however, that in addition to winter hardiness some of the hybrids yield considerably more than the Red Russian and Little Club.

As will be seen later, the advantage in yield of the hybrids is even greater in the tests made by farmers, after seeds were distributed to them, than on these experimental plats. It appears to be quite safe to say that the hybrids will yield an average of five bushels more per acre, under general field conditions, than Red Russian, and in many tests, under field conditions, the difference has been as much as ten bushels, and in some cases even more.

The distribution of seed to farmers began in 1907. Those hybrids which had proved most promising at the experiment station were distributed. Through the kindness of President E. A. Bryan, of the Washington State College, I am able to present below the following reports of farmers who have grown some of these wheats.

C. B. Kegley, Master of the Washington State Grange, reports: "My hybrid wheat averaged a little over more than 40 bushels per acre. My Red Russian averaged 25 bushels. The two fields join, the soil is the same, the ground was cultivated the same way, and sown at the same time, the seeder going from one field to the other, part of both being planted the same day. The hybrid wheat is worth from two to four cents per bushel more than the Red Russian. With an increase of 40 per cent in the yield and the two to four cents additional on the price further comment seems unnecessary. It costs no more to raise an acre of one than of the other."

A. J. D. Cornelius, of Colfax, who grew nearly 5,000 bushels of hybrids 123 and 128 this season, says: "I can safely say that these wheats outyielded standard varieties grown under similar conditions by at least ten bushels per acre."

Osborne Bros., of Coulee City, report No. 128 as much superior in yielding power and ability to stand without shattering to anything they have ever tried.

E. C. Bratt, Plaza, reports: "No. 128 outyielded any winter wheat I have heard of in this immediate locality."

Karl Gerhard, Hatton, writes: "I threshed 13 sacks of wheat from one sack of seed I got from you. Owing to the hot weather and the winds it shriveled some and did not yield as well as under favorable conditions, this being a bad year. I find it does not shell out as easy as the old kinds and the straw is strong. Had we had normal weather conditions I am satisfied the yield would have been large. I will sell none of the wheat as I want to sow all of it this fall."

A. F. Suksdorf, Spangle, writes: "I am well pleased with the hybrid wheats. I am well satisfied that No. 108 will go ten to fifteen bushels more than Gold Coin."

Mr. H. E. Schreck, LaCrosse, writes; "I have hybrid No. 63 which made a phenominal growth. I have it headed since July 19. I expect a full forty yield. P. W. Cox, Hay Station, reports No. 63 ahead of anything on his farm and Mr. Guske, LaCrosse, thinks that nothing equals No. 123. I headed Chas. Schreck's No. 63 and found it good for forty bushels. The report from Mr. Clemans it that it is ahead of all other crops."

In a later letter Mr. Schreck says: "Hybrid No. 63 gained quite a notoriety and I am sending small lots all over eastern Washington, Eastern Oregon, some orders from Montana, one from Juliaetta, Idaho, and have orders from Ogden, Utah. I shipped a car of 435 sacks to Hooper, Washtunca, and Connell."

Girard Clark, Albion, writes: "No. 123 was fine, making over fifty bushels per acre and testing 63 pounds. I sold all I had to spare at $1 per bushel. I have grown both wheat and oats on the land where I sowed the college grain last year, and have done some experimenting of my own with all of the best varieties known to the farmers of this section, but I never have secured such good results from any of them as I did from these hybrids this year, and it was not a particularly favorable season either. The grain not only yielded far heavier than any

other that I have ever grown, but the quality was also superior. Neither does the wheat shatter so much as the common kinds grown heretofore, nor do the "college oats," as they are commonly called, lodge to any great extent, although the growth is rank. The straw is sturdy enough to support the weight of the heads, even during heavy winds and rainstorms, and though beaten down by the storm the greater portion of it will rise again as soon as it dries."

President Bryan informs me in a letter dated February 23, 1909, that there was sown of these hybrids, in the fall of 1908, according to very careful estimates, 39,000 acres.

It now seems likely that these hardy wheats will add at least five bushels per acre to the yield of wheat in Eastern Washington. They are of course also adapted to adjacent portions of other states.

This work is an instance of how science may come to the aid of the farmer. It is only in recent years that scientists have turned their attention to the practical problems which confront the farmer on every hand. The results have been gratifying. They have not only been helpful to the farmer but the recognition of the value of scientific research has given popular support to it; and even those scientists who formerly boasted that they pursued science for science's sake have been brought to see that science for humanity's sake is something better, and that the object of all scientific work should be to render service to mankind.

LIST OF BULLETINS

The following bulletins of this Station are now available for distribution. Copies of them may be obtained free of charge by writing to the Director of the Exepriment Station, Pullman, Wash. Missing numbers are out of print.

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State College of Washington
Agricultural Experiment Station
PULLMAN, WASHINGTON

DEPARTMENT OF HORTICULTURE

Forest, Shade and Ornamental Trees in Washington

By W. S. THORNBER

BULLETIN No. 90
1909

Fig. 1. A Group of Colorado Blue Spruce

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Introduction

The large number of communications asking for help and suggestions along forest and shade tree problems, and the almost universal desire of improving the rural as well as the village and city homes of our state, have suggested the publication of this bulletin.

Bulletin No. 12 of this station, published in 1894 by Professor Balmer, gave valuable advice to the early planter and now since many of the trees planted two years previous to that time have made splendid growths, it seems advisable to publish another report upon their behavior with the additional notes that it has been possible to secure from various parts of the state.

During the past fifteen years the Experiment Station has tested a large number of species and varieties of trees and while a few have proved too tender or have too readily succumbed to disease or insect pests, yet a remarkably large number have made very creditable showings.

The plantations of shade and forest trees made by the early settlers in various parts of the state are today the most valuable guides for future plantings that one could desire. While in some cases these early plantations are only the tombstones of an ambitious planter's efforts, yet in most instances they stand out prominently as valuable sugestions for the present day planter.

The question of what to plant has, to a certain degree, been settled, and now no one need plant a Box Elder or Lombardy Poplar, feeling that they are the only trees that will make a rapid growth or withstand our long, dry summers. Our list of

tested trees has been extended until now one could secure over a hundred different species that have been thoroughly tested and found satisfactory in this state.

One of the primary needs of the planter of today is more knowledge relative to the time, manner of planting, and care of the trees. More young trees are killed at the time of transplanting by simply ignoring four or five elementary principles of transplanting, than die from all other troubles in the following years.

It is very gratifying to note the interest that is felt in tree planting in the wooded as well as treeless areas of the state, both for ornament and for shelter and the appreciation of the improvement made by judicious planting about the home.

While the recommendations made in this bulletin as to the behavior of trees are primarily based upon Eastern Washington conditions, yet we feel that they will generally apply to all parts of the state since the writer has secured information in various ways from many parts of the state, and also believe that whatever will do well here will do well in other parts of the state. It is hoped that the information given will result in increased planting in cities, towns, and rural districts, thus adding to the pleasures and attractions of our state.

PART I

Propagation of Forest and Shade Trees

The person who contemplates planting trees must either grow his own trees from seed or cuttings, or buy them from a nursery. The buying of shade trees from a nursery seems to incur more expense than men feel able to bear, yet it is often more economical than to attempt to grow them on the farm. If one is fortunate enough to live near a native timber he can frequently secure many valuable trees at a minimum cost, and yet if he must hire teams and help to secure these trees, the chances are that they will cost him twice as much as better trees of the same species and size from the nursery. I do not wish to discourage the idea of bringing wild plants from the woods to our homes and yet I feel that after considering all expenses, this is not an economical plan to pursue.

Frequently, one may secure many valuable small trees from the woods and after growing them for a year or more in nursery rows, they will be first class for all kinds of planting. This is usually the best plan to follow when transplanting small evergreens from the forest, since they are usually slender, poorly rooted, and not adapted to the conditions common to lawns and parks.

Cutting and Grafting. A great many of our forest and shade trees, such as willows, cottonwoods, and aspens may be propagated from cuttings taken any time after the leaves fall and before the trees start into growth in the spring. Usually the best time is late in fall or early in the winter before the hard winter freezing has had a chance to lower the vitality of the

young branches, but good trees may be secured from cuttings taken very late in the spring.

The best materials to use for cuttings is the present year's growth, although material much older may satisfactorily be used. These switches should be made up into cuttings about seven inches long with the lower end cut from an eighth to a sixteenth of an inch below the bud. This is to insure more reserve plant food for the immediate development of callus and new roots, than is possible to secure farther from the buds. Little or no attention need be paid as to where or how the top cut is made.

If the soil is in proper condition these cuttings may be planted as soon as they are made, or stored in pits or boxes in moist soil, saw dust, or moss, until early spring and then planted either where they are to grow into trees, or in nursery rows for one or more years.

When a hedge of willows is desired or a wood lot is being planted, it is usually best to plant the cuttings where they are to grow, otherwise we grow them for one year in rows where thorough cultivation is possible.

Occasionally we desire trees that can not be successfully propagated from cuttings, seeds, or suckers and so it is necessary to graft them. Last year we propagated a nice bunch of Thorn trees (Crataegus) by grafting them upon common apple stocks. The union was perfect and the trees are now apparently as good as seedlings of four or five years' growth.

Growing Trees From Seed. One must be thoroughly familiar with the habits of trees to know when it is best time to collect the seeds for planting. As a general rule they should be gathered as soon as they are ripe, and even before this if there is danger of squirrels or birds taking them. While this is practically the same time each year for certain species it does not follow that all trees of the same genera ripen their seed at the same time. For example, the Red and White Maples mature their seed in June while the Norway, English, Sycamore, and many others do not mature their seed until October or November.

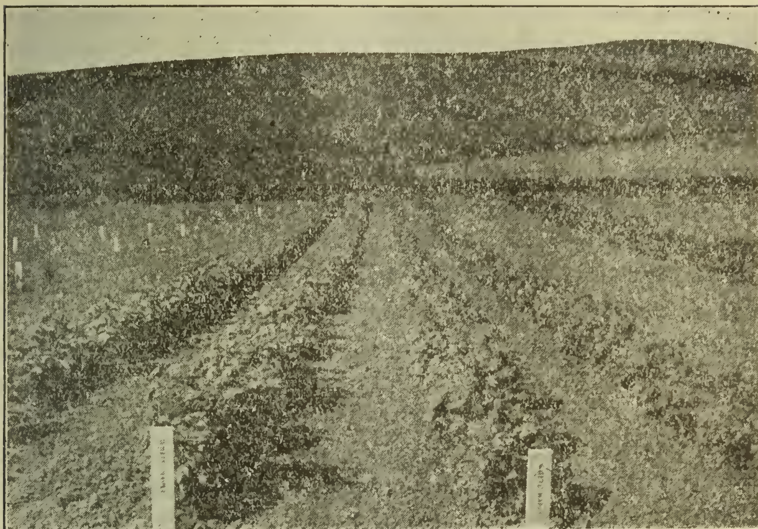

Fig. 2. White Maple from Seed Planted in June
Photo taken in September

Fig. 3. Two year-old White Maples

Great care should be exercised as to the condition of the trees from which the collector secures his seed. A much better lot of seedlings may be secured from a group of healthy trees than from a stunted, crowded, diseased, or even shaded trees. Some of our American trees are already showing the evil of this indiscriminate method of securing seeds, and so it behooves us to use even more care from what we propagate than we do for corn, wheat, and other farm crops.

The seeds of Red Maple, White Maple and Elm ripen the last of June and should be gathered and planted at once or mixed with moist sand and stored in a cool cellar until fall or even the following spring. It is usually best to plant at once and by so doing secure a few inches of growth before fall.

In the case of the Red Maple it will be necessary to provide a slight shade of some sort, as the young plants are very tender and will sun-scald or die outright unless protected.

The seeds of most of our common trees: i. e. Ash, Locust, Norway, Sycamore, and English Maples, Hackberry, Oak, Birch, etc., ripen during October and should be gathered and planted at once or stratified in twice their amount of sand and stored in a cool, shady place and kept moist until early spring, when they should be planted in nursery rows. While most of these seeds will germinate without freezing during the winter, it is preferable to have them freeze.

Sometimes the seeds of Catalpa, Box Elder, Green and White Ash remain on the trees until late winter or early spring. These may be gathered and planted at once, but it is not a safe plan to depend upon their clinging so late as winter.

The seeds of the Honey Locust, Coffee Bean Tree and a few others are always slow about germinating. This may be hastened by pouring boiling water over the seeds and allowing them remain in it until the water cools. Then sift or pick out all seeds that have begun to swell and treat the remainder to another scalding and so on until all have become swollen, after which they must be planted at once in moist soil or they will perish.

Ash, Box Elder, Black Locust, Catalpa, and Hackberry seeds may be stored dry, providing they are carefully dried out before putting away and are kept in a cool, rather moist, not damp, room. In the spring they must be soaked a few hours before planting in order to hasten germination.

The collecting of Pine, Spruce, and Fir seed requires a little more skill and care. In this climate most of these start to ripen the latter part of August or early in September. It is necessary to gather the cones before they have started to open since the very best seeds are apt to scatter out early. After gathering the cones they should be drid in a warm, not hot, place when they will readily open up and with the least moving or beating the seeds will readily thresh out. If the cones become moist or wet after partially opening they will close up again and will have to be dried again before opening.

When evergreen seeds are gathered in large quantities, cool ovens or buildings with specially constructed slat trays are provided which materially simplifies seed saving.

Planting of Seeds. When the soil is in good condition, neither too wet nor too dry, fall planting is preferable, providing they are mulched with leaves, straw, or coarse litter to prevent heaving out, washing out, or drying out during the winter. However, it is the safer plan to prepare the land in the fall and plant as early as possible in the spring. This planting must be done before the seeds have started to germinate or many will be lost during planting.

The seed bed should be thoroughly prepared before planting, as this will save lots of hard labor later in the year. The seeds of deciduous trees should be planted in band rows six inches wide, two inches deep in fall and from one to one and a half inches deep in spring, and the rows from three to four feet apart. By using this method a good stand of trees may be secured and so many more can be grown per acre than is possible in the narrow row system.

The soil should be packed firmly around the seeds to prevent drying out during or after germination. The deep planting is necessary in dry soils, in order to help the plant develop

roots that will stand the dry summers. If the above method be followed with proper tillage one will have no difficulty in raising first-class seedlings.

The evergreens require an entirely different treatment than we give the deciduous trees. The seed-bed should be divided into plots four feet wide and of indefinite length. Two or more beds may be established side by side with four foot paths between them to permit the care that they will demand. Some protection or shade will be necessary for at least two years. This may be six feet above the beds and cover the paths as well as the beds or less than two feet above the plants and cover only the plant beds. However, the tall shade is best since it permits a better circulation of air. This screen may be made out of laths, strips, or even prunings from an orchard. Anything that will shut off about one-half of the light and heat of the sun is usable.

One should not attempt to grow evergreens from seed unless he can provide the seed-bed with plenty of water whenever it is necessary and is willing to give it careful attention during the first two or three months after planting. These little trees are very subject to insect pests and plant diseases, which quickly destroy thousands

Mr. C. W. Guerney of Yankton, South Dakota, a pioneer nursery man of the plains regions, has an interesting as well as successful method of growing evergreens from seed. Since most of the difficulty in growing evergreens from seed comes through "damp off" of the young plants, Mr. Guerney has been and is experimenting along the lines of growing the plants in sterilized flats and soil. He also sterilizes the seeds before planting and waters them afterwards only with sterilized water. In this way he has practically eliminated loss from "damp off" and now is producing better trees for less money than in the past.

Transplanting of Trees. The transplanting of a tree, whether it be small or large, usually checks its growth, and while this check is not always detrimental, yet it usually reduces the total growth for the succeeding two or three years.

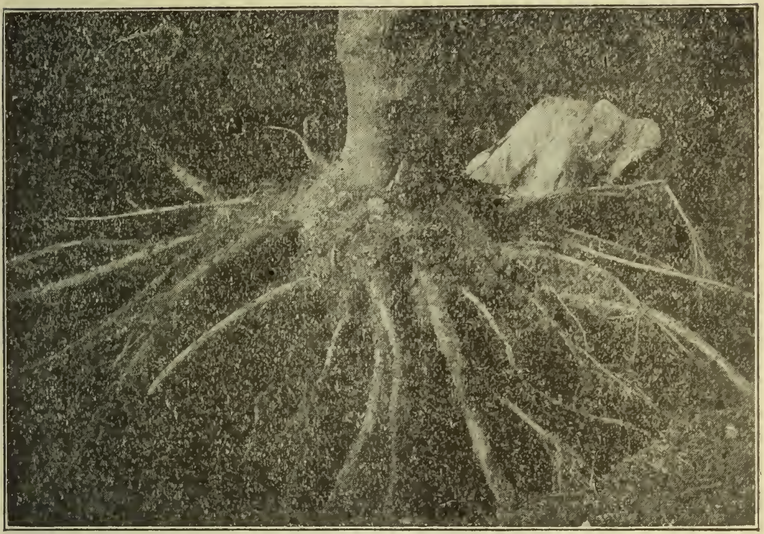

Fig. 4. The Proper Way to Dig a Large Tree for Transplanting

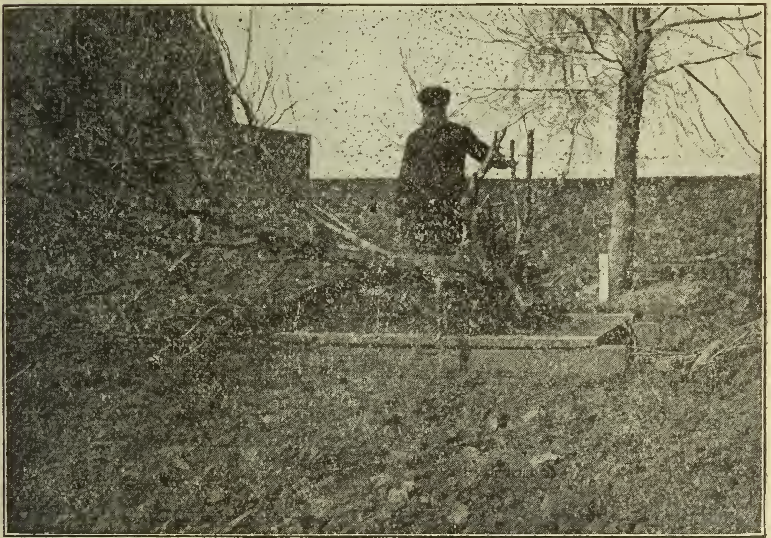

Fig. 5. A Convenient Method for Moving Large Trees

This general check is caused by the loss of roots which takes place in digging the tree. It matters little how carefully a tree may be dug, it will suffer a severe loss of roots and in many case from one-half to three-fourths of its entire root system, and practically all of its feeding roots will be lost. Another very severe check is caused by the roots becoming dry during transplanting. This not only kills the small roots and hardens the bark of the larger roots, so as to make it difficult for them to form new rootlets, but in the case of the evergreens it hardens the sap which is resinous, and thus kills the tree. It is impossible to exercise too much care in the digging and transplanting of trees in dry severe climates.

Deciduous Trees. This group if trees includes practically all trees that lose their leaves at the approach of winter, with the exception of tamaracks and larches which are grouped with the evergreens. Common examples of this group are: Maple, Ash, Elm, Birches, Catalpa, Poplar, etc. Although deciduous trees are usually transplanted more carelessly than evergreens, from close observation one readily sees that extra care is amply rewarded by better and more satisfactory growth.

The time or season of the year for transplanting deciduous trees is governed by the development of the tree, the condition of the soil, and the weather that is apt to follow transplanting. Many trees may be successfully transplanted at any time during their dormant or leafless period, while others require that transplanting be done at certain seasons of the year. If the trees are fully matured, the soil moist, not wet, and the winters are not too severe, one may feel safe in fall planting. If the soil is wet and poorly prepared and the trees are not well ripened off, it is safer to plant in early spring. From the nature of our springs in Eastern Washington the very early spring planting fare the best, while the late planting suffers materially on account of the severe drought of late spring and early summer.

Secure your trees in the fall or during the winter, and when the first fine days of spring come, even though they be in February or March, proceed at once to plant.

One of the principal reasons why Eastern nursery stock does not do as well as home grown stock is due to the fact that some of these nurseries make no shipments before the twentieth of March and since it takes almost or quite a month for a shipment to cross the continent, they frequently do not reach here in time to receive the benefit of the best part of the season.

Deciduous trees should be planted from one to two inches deeper than they grew in the nursery. Thoroughly pulverized moist earth should be worked in among the roots, until the hole is about half full, and then this earth should be tamped or tramped until it is solid. The tramping of the earth around the roots of the tree is one of the most important features of transplanting a tree. It serves a dual purpose; first, by holding the tree firm while new roots are being formed, and second, in retaining moisture, which is so essential to its growth.

Water may be applied to the hole either the day before the trees are planted or after the hole is half full of earth, but if the soil is moist it is usually best not to use any water. The upper half of the soil that is filled into the hole may be left loose or only lightly tramped, and the surface left loose and finely pulverized. This will serve as a mulch or protection as well as take up any water that may fall on the surface.

Evergreens. The transplanting of evergreen trees is always accompanied by more or less risk of losing a small percentage under favorable conditions to a large percentage or even total loss under unfavorable conditions. They are much more difficult to transplant successfully than deciduous trees, but if the proper time to be selected, the trees be properly handled during the time they are out of the ground, the manner of planting be not too faulty, and the care they receive after transplanting be at least reasonable, one may usually expect success.

If the proper care be exercised, an evergreen tree may be transplanted any month during the year, but there are times when it is easier to attain success than at other seasons.

Probably the most favorable time for transplanting evergreens is in spring either just before or just after they have started into growth. Trees transplanted at this season of the

year start into growth at once and in many cases they do not receive a perceptible check. Last spring at one time three hundred evergreens, consisting of Douglas Fir, White Fir, Engleman's Spruce, and Jack Pine varying from six inches to several feet in height were dug in the mountains north of Pullman and transplanted to the campus and various home lots, just as the buds were expanding. These trees were each dug with a small ball of earth clinging to their roots, and then carefully bound up in a piece of burlap. They were carefully planted and received on an average only reasonable care during the hot, dry summer. At the present time over ninety-eight per cent of these trees are alive and doing well. And so we feel safe in recommending this season of the year as a very favorable time to transplant evergreen trees.

Early in the summer or just as soon as the young growth has hardened is another favorable time to transplant evergreens. A tree set at this season of the year makes no top growth until the following spring, but the cut roots fully callous over, and numerous small roots are usually thrown out preparatory to the spring growth. The trees will become established before winter and other things being equal, will be better prepared for spring growth than one set the following spring. In a dry hot climate the roots and soil should be thoroughly soaked at planting time and a good mulch of coarse straw or litter will be very beneficial during the hot, dry season that is almost sure to follow. Last August we transplanted fifty small evergreens and gave them the above treatment. At the present time there are forty-six alive and in good growing condition. While we are not so successful as in spring yet considering the dry weather that followed the planting we have no cause for complaint.

Evergreens may be successfully transplanted during the winter months, provided a ball of earth, preferably frozen, be taken intact with the roots of each tree. This ball of earth must be permitted to thaw out while it is exposed to the air, or the tree is apt to die. This method is employed in the transplanting of large trees that are to be moved a comparatively

short distance. Various means are used to secure this ball of earth intact. Probably the more common way is to dig a narrow trench around the tree before the ground freezes and fill with straw or litter until the ground freezes. It is then a comparatively easy task to load the ball of earth upon a low wagon, or stone boat and move it to another hole which has been previously prepared for the tree. Loose earth must then befirmly packed around the tree to shut out all air from the roots. In localities where the soil does not freeze deep enough to permit handling in the above manner, a suitable box crate may be constructed which will hold the soil intact during the transplanting. This method is a little more expensive, but may be successfully used for handling large trees in the winter time.

Fall planting has been successfully used in many localities, and where all conditions are favorable it is a safe venture, but if the soil is dry we favor the spring or summer seasons for moving evergreens.

A great many evergreens are transplanted every year very early in the spring; but this seems to be a very unfavorable season of the year to disturb them, since the roots are apt to become frosted or dried out before they can be planted, consequently a large percentage of the trees transplanted at this season die outright or live only to make weak poor trees. Early in the spring of 1906 we attempted to transplant a few spruce, fir, and pine, by digging them with a ball of earth and tying each up in burlap, during the period of transplanting. A cold snap came on and many balls were frozen solid. As a result 95 per cent died.

From our experience with evergreens we favor either late spring (and by this we mean the few days preceding the time the tree starts into growth and the first week of its growing period) or the period at the close of its growth. This latter period is usually during the last half of July or early in August. In the former period the sap is just beginning to move so the tree continues to grow and in many cases receives no perceptible check, while in the latter the sap has practically ceased

to move and so the tree has almost a year to establish itself in its new place.

No evergreen however small can be dug and transplanted without at least some injury to the roots. Since the roots of the most of them and especially of pines are very tender and soft, it not infrequently happens that the bark will be peeled off in many places, and since the sap beneath the bark is extremely resinous and the least exposure to sun or wind causes it to harden, too much care cannot be exercised in order to avoid this difficulty, for if the sap once becomes hard the tree is sure to die.

Large deep holes with plenty of loose moist soil in the bottom should be provided for any tree but especially is this true of an evergreen. During transplanting the roots must never become dry either by the wind or from the sun. This is best avoided, if one is compelled to transplant evergreens during a bright, sunshiny day, or even in the wind by puddling which consists of dipping the tree roots in a tub or barrel of liquid clay. While the trees are not so nice to handle after this treatment, it serves its purpose well, not only as a protection against the sun and wind but also against dry coarse lumps of soil from coming in contact with the tender roots. Another very important phase in the transplanting of a tree, and especially is this is true of the evergreen, is to make the soil very, very firm around its roots. If the soil is well prepared and in proper condition it will be almost impossible to make it too firm. This packing of the soil may be done in one or two ways: either by the planter tramping it with his feet or by using a two by four, or even a four by four tamper. Care must be exercised, however, not to injure the tender roots. This may be avoided by working loose moist soil in among the roots until they are all well covered and the hole half or two-thirds full and then it should be packed. More newly transplanted evergreens die on account of the planter failing to make the soil firm about the roots, than from any other single cause. This is the only safe way to exclude the air from the roots, and unless this is done failure is sure to follow.

The soil near the surface should be left loose so as to act as a mulch and a medium to take up water during light rains.

If it is deemed necessary to water the trees during the dry part of the summer, apply it only in large quantities, and be sure the soil is thoroughly soaked before you quit. A light watering or even frequent light waterings are always more injurious than beneficial, if the soil is permitted to crust or bake between waterings.

When clean culture is not possible, as is frequently the case on lawns in parks, and with street trees, it is best to apply a good heavy mulch of coarse litter, rotten straw, or even forest leaves, and apply the water to this rather than to the bare ground. It has been our experience that one or two good waterings during the summer when applied to the mulch is far better than keeping the surface soil wet without mulch. The mulch not only retains the moisture, but also keeps the soil cool, adds plant food, and aids in the pulverizing of the soil. It must not wholly take the place of culture, since the tree will be materially benefitted by occasionally raking off the mulch and thoroughly working up the soil and then recovering with the same mulch.

Wind Breaks and Shelter Belts. The question of wind breaks and shelter belts is one that has been discussed in all new countries since men learned to plant and care for trees and while under certain conditions a wind break may become injurious to an orchard, it has never been known, where properly constructed, to be detrimental to the farm home and its surroundings. Entirely too many of our Eastern Washington farms are devoid of trees of any kind. This is surely a deplorable condition and one that should not be permitted to exist longer than is really necessary.

There is no phase of work that could improve our country more than liberal plantations of all kinds of trees around the farm buildings and in many cases along the public highways. I would not plant hedges along the road, as valuable as they might be; nor would I plant fruit trees, since these trees are apt to become the breeding grounds of injurious insects. We

have a large list of trees that one can select from for roadside planting that will harbor no insects, or plant diseases, that are apt to become injurious to either horticultural or agricultural crops.

If the planter desires a deciduous wind break and yet can spare room for only one row of trees, it will be best to plant closely Black Locusts, Lombardy Poplars, White Willows, Box Elder, Balm, or even Carolina Poplars. While if he wishes to make a wind-break of a single row of evergreens, it will be best to plant Bull Pine, Scotch Pine, White Spruce, Engleman's Spruce, Norway Spruce or even Douglas Fir. Any of these trees properly planted and cared for will soon make an effective as well as an attractive wind-break.

If it is possible to devote more land to the growing of the wind-break, a much more effective and useful one can be grown by planting several rows of evergreens and deciduous trees together. Two general plans are in use at present; one consists in planting the tall growing evergreens in the middle of the band and filling in on each side with slower growing evergreens and deciduous trees, finally planting a row of low, dense shrubs on each side to act as a check to snow and the wind that would go under the crowns of the tree. The other consists in planting the tall dense evergreens on the inside with deciduous trees and other evergreens on the outside; finally, having one row of low dense shrubs on the extreme outside to act as a snow or low wind-break. The former plan is usually more satisfactory although the latter has many ardent admirers.

Aside from the material benefits in posts and fuel that one could sécure from these shelter belts and roadside plantings, there are unmeasured pleasures and comforts to be gained from thm, not only to the farmer and his family but also to his stock. Man and beast instinctively seek shelter of the trees from the hot sun of summer and the cold blasts of winter, and so why not provide these comforts.

At the present time several counties are attempting to introduce foreign birds of economic importance. This is a royal move and while our orchards, vineyards and berry fields af-

Fig. 6. Winter Injury. Oregon Ash (on the right) killed; Flowering Ash (on the left) uninjured

Fig. 7. A Group of American Mountain Ash

ford good nesting places, they afford poor winter protection, since our improved methods of culture demand that weeds be kept out, and our system of growing first-class fruit necessitates severe pruning which might otherwise afford protection to these birds.

The area of land to be devoted to a wind-break will in a measure govern the kind of trees to use and the method of planting.

When it is possible the wind-break may become the woodlot of the farm which not only economizes but also insures a larger and better shelter belt for the farm buildings.

The Wood Lot. A wood lot is a plantation of trees whether natural or artificial, for growing wood for fuel, fence posts, poles, stakes, etc. It is to the farm what the work-basket is to the house-wife, and while it is frequently given the poorest soil of the farm, which usually consists of a washed hillside, a rocky corner, or even a semi-marshy field, yet, in time, if proper trees be planted, much valuable material may be taken from it.

The purpose of the wood-lot is not to grow timber, since this would require too long a period, but rather to grow the more rapid growing sorts, which will begin to produce material, fuel, and fence post size in from five to seven years from planting. Much, of course, will depend upon the nature of the soil, the amount of rainfall, but more especially upon the kind of trees used.

If the land is low, very moist, or even wet, the cottonwood, willow and European Larch will probably be the best kinds to use, since under these conditions, they are very rapid growers, as the growth table will show and while the wood of these trees is not of a high fuel value, yet if it is properly cured after cutting it will be as good or better than much of the fir and pine wood that is found on our markets at the present time. On fairly moist soil, it would be better to plant a few of these rapid growing trees to act as fillers, which are to be removed as soon as they begin to crowd the permanent ones, but make the major portion of the plantation of Sycamore Maple and White Maple, Green and Flowering Ash, Black Locust, Austrian Pine, Doug-

las Fir, Black Walnut, and European Larch. These trees have all made splendid growth in our plantations. We are of the opinion that at the present price of fuel every farmer who does not have native timber upon his place could well afford, from a financial basis, to plant from five to ten acres of trees for wood-lot purposes.

Pruning. Shade trees should receive practically the same regular pruning that fruit trees do, except that since they are to produce wood and foliage, all pruning should be done during the winter in order to encourage wood growth. The framework must be developed from carefully selected limbs with wide angles and strong crotches. A strong central shaft should be preserved in the young tree in order that the top may be raised as it grows older. A small amount of thinning should be done but not carried to excess. Prune back each winter to live buds and branches, never leaving stubs or spurs. If the tree becomes top heavy, cut back in the summer time; otherwise do not.

Evergreen trees require little or no pruning. When it is desirable to thicken the top, cut back to buds or branches, never disturbing the terminal bud. Evergreen hedges may be sheared the same as other hedges.

PART II

Notes on Growth of Trees

Bulletin No. 12, of this Station gave in detail lists of trees planted on the College and Station grounds in 1892-1894, with notes on the first two seasons' growth of most of them. Following the resignation from the Experiment Station staff of Prof. J. A. Balmer, the original planter of these trees and author of the Bulletin, no particular attention was given to the plantation for a few years, except the necessary cultivation of the soil in certain parts of it. Beginning with 1900, however, regular measurements of the annual growth, notes on hardiness, etc., were taken. The facts thus gathered are presented in the following pages.

Rapidity of Growth

The following table of measurements reveals some very interesting facts relative to the rapidity of growth of some of our more common trees. These data have been secured by the measuring of a number of trees and averages found from these figures. The trunk diameters were secured much in the same way using one foot from the ground as a standard of height for all measurements to be taken. Interesting comparisons can be made between the total height and the trunk diameters of many of the trees. An interesting fact is seen in the case of the two Larches. The European Larch while of the same age as the American is almost twice as large and has from two and one-half to three times as much wood in it. Thus showing its value as a fuel producing tree. The European Larchs compare very

		Age	Average A… growth 1900-1…	Total H…	Diameter one foot f…	Cu…
Tilia vulgaris						
Ulmus Americana	American Elm	15	21	22	7 ¼	Cultivat'd
Ulmus Scabra	Scotch Elm	15	15	25	7 ½	Cultivat'd
Abies Grandis	Western White Fir	15	32	28	7 ¼	Grass
Abies balsamea	Balsam Fir	15	12	21	7 ¼	Grass
Juniperus Virginiana	Red Cedar	15	12	8 ½	*	Grass
Juniperus communis	Irish Juniper	15	14	10 ½		Grass
Larix Americana	American Larch	15	32	21	7 ¼	Grass
Larix Europea	European Larch	15	37	35	14	Grass
Picea Alba	White Spruce	15	8 ½	7 ½	3 ¼	Grass
Picea Engelmanni	Engelman's Spruce	15	21	21	5	Grass
Picea Excelsa	Norway Spruce	15	30 ½	25	6 ¼	Grass
Picea Nigra	Black Spruce	15	8	6 ½	4 ¼	Grass
Picea pungens	Colorado Blue Spruce	15	18	14	5	Grass
Pinus Alba	White Pine	15	36	28	9 ½	Grass
Pinus Divaricata	Western Jack Pine	15	19 ½	15 ½	6	Grass
Pinus Montana	Dwarf Mountain Pine	15	17	17		Grass
Pinus Ponderosa	Bull Pine	15	16 ½	18 ½	5 ½	Grass
Pinus Sylvestris	Scotch Pine	15	16	18	7 ¼	Grass
Pinus Lauricio	Austrian Pine	15	27	24	10	Grass
Pseudotsuga Douglasii	Douglas Fir	15	29 ½	30	8 ½	Grass
Thuya occidentalis	Arborvitae	15	9	12	3 ¼	Grass
Thuya Gigantea	Giant Cedar	15	15	11	3	Grass
Thuya occidentalis, var	Dwarf arborvitae	15	1	1 ¼	2	Grass
Thuya occidentalis, var	Blue arborvitae	15	12	13 ½	3	Grass
Chamaecyparis sphaeroidea	White Cedar	15	11	10	2 ½	Grass

Scientific Name	Common Name	Age of Tree	Average Annual Height [illegible] 1900-1907 inclusive	Total Height of Trees	Diameter of the Trunk one foot from the ground	Cultivation or Grass
			inches	feet	inches	
Acer Campestris	English Maple	15	23	24	8	Cultivat'd
Acer Circinatum	Vine Maple	15	18	20	4	Grass
Acer Macrophyllum	Oregon Maple	15	37½	22½	*	Cultivat'd
Acer Platanoides	Norway Maple	15	22¼	21	6½	Cultivat'd
Acer Pseudo-platanus	Sycamore Maple	15	18	24½	7½	Cultivat'd
Acer Rubrum	Red Maple	15	28½	20	5¼	Cultivat'd
Acer Saccharinum	White Maple	15	35½	27	8¼	Cultivat'd
Acer S. Wierii	Cut-leaved Maple	7	24½	13½	3	Cultivat'd
Acer Saccharum	Sugar Maple	15	20½	19½	4	Cultivat'd
Acer Negundo	Box Elder	15	21	21	7	Grass
Aesculus Glabra	Buckeye	16	16	22	7½	Grass
Aesculus Hippocastanum	Horse Chestnut	15	12	18¼	7½	Cultivat'd
Alnus rubra	Red Alder	15	17	16½	4	Cultivat'd
Amelanchier Alnifolia	June-berry	15	21	31	10	Cultivat'd
Betula Alba	White Birch	15	20½	33	9	Cultivat'd
Betula A. pendula	Weeping White Birch	15	17	15	5	Grass
Betula lutea	Yellow Birch	15	23	17	7	Cultivat'd
Catalpa bignonoides	Catalpa	15	18½	15½	8	Cultivat'd
Catalpa ovata	Kaempfer's Catalpa	15	16	15	7	Cultivat'd
Catalpa speciosa	Hardy Catalpa	15	16	15	5½	Cultivat'd
Castenea Americana	American Chestnut	13	22	15	5½	Cultivat'd
Castanea crenata	Japanese Chestnut	15	16	18	4¼	Cultivat'd
Carpinus Caroliniana	American Hornbeam	15	19¼	23	8½	Cultivat'd
Celtis Occidentalis	Hackberry	15	20	23	7	Cultivat'd
Fraxinus Americana	White Ash	15	23	22	8	Cultivat'd
Fraxinus Lanceolata	Green Ash	15	23	23½	7½	Cultivat'd
Fraxinus Orogona	Oregon Ash	15	27½	32	10½	Cultivat'd
Fraxinus Ornus	Flowering Ash	15	18	13¼	3	Grass
Gymnocladus Canadensis	Kentucky Coffee Tree	15	24½	17½	6½	Cultivat'd
Juglans cinera	Butternut	15	26	24	5	Cultivat'd
Juglans nigra	Black Walnut	15	18	19	5	Grass
Morus alba	White Mulberry	15	23	28	8½	Cultivat'd
Platanus occidentalis	American Plane	13	26	32	10	Grass
Populus alba	Silver Poplar	15	19	27	7	Grass
Populus balsamifera candicans	Balm of Gilead	15	43	50½	14	Grass
Populus Deltoides	Cottonwood	15	30½	36½	7½	Grass
Populus Nigra Italica	Lombardy	13	19½	36¼	7½	Grass
Populus tremuloides	American Aspen	15	18	21	7	Cultivat'd
Prunus serotina	Wild Black Cherry	15	16	16½	4½	Grass
Prunus spinosa	Blackthorn	15	22	19¼	5	Cultivat'd
Prunus Virginiana	Chokecherry	15	15	16	3	Grass
Quercus alba	White Oak	15	22	15	3	Grass
Quercus coccinea	Scarlet Oak	15	21	21½	5	Cultivat'd
Quercus Prinus	Chestnut Oak	15	15½	36	10½	Cultivat'd
Quercus sessiliflora	English Oak	15	24	27	9	Grass
Robinia pseudacacia	Black Locust	15	36	45	13	Grass
Salix blanda	White Willow	14	38	29	9¼	Grass
Salix Vittellina	Golden Willow	15	16	16	4½	Cultivat'd
Sorbus Americana	American Mountain Ash	15	13	14½	7	Cultivat'd
Sorbus aucuparia	European Mountain Ash	15	11	14½	7	Cultivat'd
Sorbus sambucifolia	Elder-leaved Mountain Ash	15	11	13½	5¼	Cultivat'd
Tilia vulgaris	European Linden	15	21	19	9¼	Cultivat'd
Ulmus Americana	American Elm	15	21	22	7¼	Cultivat'd
Ulmus Scabra	Scotch Elm	15	15	25	7½	Cultivat'd
Abies Grandis	Western White Fir	15	32	28	7¼	Grass
Abies balsamea	Balsam Fir	15	12	21	7¼	Grass
Juniperus Virginiana	Red Cedar	15	12	8½	*	Grass
Juniperus communis	Irish Juniper	15	14	10¼		Grass
Larix Americana	American Larch	15	32	21	7¼	Grass
Larix Europea	European Larch	15	37	35	14	Grass
Picea Alba	White Spruce	15	8½	7½	3¼	Grass
Picea Engelmanni	Engelman's Spruce	15	21	21	5	Grass
Picea Excelsa	Norway Spruce	15	30½	25	6¼	Grass
Picea Nigra	Black Spruce	15	8	6½	4¼	Grass
Picea pungens	Colorado Blue Spruce	15	18	14	5	Grass
Pinus Alba	White Pine	15	36	28	9½	Grass
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Thuya occidentalis, var	Blue arborvitae	15	12	13½	3	Grass
Chamaecyparis sphaeroidea	White Cedar	15	11	10	2½	Grass

›rably with any tree of the same age even the Cottonwood Lombardy Poplar group. Some of these trees are growing grass while others are in cultivated lands.

TREES

The following facts concerning the habits of growth of the ferent species of trees as described were collected largely om the experimental tree planting on the College campus and periment Station, with additional notes from plantings in ferent parts of the state.

ACER Campestre, Linn. English Maple. Native of Europe and stern Asia. A medium to rapid growing, round topped tree with npact head, numerous small branches and an abundance very pretty, small, dark, green leaves. It starts into owth early in spring, holds its leaves rather late in the fall, and en full of ripening seeds is very attractive. As a small street or ade tree it has few superiors, standing drouth and dust as well as nty of moisture. It is easy to transplant and propagate and should extensively used in all ornamental planting.

A. Circinatum, Pursh. Vine Maple. Native of Western ited States. This is a small tree or large bush as grown on the npus. It throws up several slender trunks from one root, none of ich ever become very large. The limbs are usually more or less ndulous in habit, which gives it the name of Vine Maple. The iage is dense and pretty, taking on beautiful autumn tints in the l. It can be used very effectively in banking and small clumps, ecially in moist soils where it grows best. The Vine Maple is per- tly hardy anywhere in the state and readily stands transplanting.

A. Macrophyllum, Pursh. The Oregon or Large-leaved ple. Native of parts of California, Oregon, Washington and Brit- Columbia. Several trees of this species are growing on the npus and while it is not hardy enough at first to produce a single mmed tree, it may become more or less acclimated in time so that can remove all but one stem of these bush-like trees and by this eans obtain a nice tree. The limbs are coarse and heavy. The ves are large and very ornamental. The Oregon Maple may be d very effectively as a screen for the back of the yard or as a wind- ak. In the Western part of the state it is the principal street e and it serves the purpose well, since it is a clean rapid growing, nse shade-producing tree.

A. Negundo, Linn. Box Elder, Ash Leaf Maple. Some form the Box Elder is a native of practically all parts of the United

States. The Box Elder is a very pretty round topped maple-like tree and is occasionally called the pioneer of shade trees, since we find it being planted usually before any other form of shade trees. It is a valuable shade and street tree for severe situations, but we find it serving its best purposes when planted along public roads or being used for a wind-break. The rapidity of its growth, denseness of its foliage, the value of its wood for fuel and the ease with which it can be transplanted all add to its usefulness for the farm or city home. Old specimens become irregular or unsightly sometimes, but they can usually be rejuvinated by severe pruning and proper care.

A. Platanoides, Linn. Norway Maple. Native of Northern and central Europe and Asia. Many good specimens of this tree are growing on the campus. It is one of our best shade and street trees, forming a dense round top with very pretty foliage and strong limbs that are not easily injured in wind storms. It comes into leaf early in spring and drops its leaves late in the fall after taking on a rich yellow or bright red color. This tree is perfectly hardy anywhere in the state, is long lived, easily transplanted and withstands drouth remarkably well. Under normal conditions it is a rapid grower and easily propagated from seeds.

A. P., Schwedleri. Koch. Schwedler's Maple. A horticultural variety closely resembling the species but having foliage that is bright red when young and purple red when older. Propagated by budding upon the Norway Maple.

A. Pseudoplatanus, Linn. Sycamore Maple. Native of eastern Europe. There are several good specimens of this tree found growing on the campus where it has proved itself to be a very valuable shade and street tree when well cared for and severely cut back occasionally in order to develop a dense crown. Naturally the top is spreading, irregular and open in habit, but severe pruning will correct this fault.

The limbs are long, pole-like, and, although the crotches are acute angled much like the White Maple, it rarely, or ever, breaks or splits in wind storms since the wood is very tenaceous.

The tops are not as dense as the Norway Maple but the leaves are large, three to five-lobed and very showy for ornamental planting. It is perfectly hardy and a rapid grower.

The Sycamore Maple, when undisturbed, forms a long, heavy tap root, which makes the transplanting of large trees very difficult and uncertain. Small trees are usually easily transplanted. It is readily propagated from seeds. The Sycamore Maple is being substituted for the Sugar Maple in some parts of the state, and it is said to produce a large quality of a fair quality of maple syrup and sugar. This is one of our best street trees.

A. Rubrum, Linn. Red Maple, Scarlet Maple or Swamp Maple. Native of the eastern United States and Canada. Good specimens of this tree may be seen on the campus or on several lawns in Pullman. It is a beautiful slender tree of an upright habit of growth with a rather compact dense crown. The Red Maple resembles the White Maple somewhat, but is a much slower grower. It is hardy anywhere in the state and withstands drouth as well as an excess of water.

It is epsecially valuable for ornamental planting, since its red blossoms come out very early in spring, and in fall the autumn effects of its foliage are not surpassed by any other plant. This tree is easily transplanted, but usually makes a slow growth for a few years or until it becomes established. It is readily propagated from seeds if sown as soon as they are ripe in June.

A. Saccharinum, Linn. Silver Maple. Soft or White Maple. Native of southeastern Canada and eastern half of the United States. A very popular as well as satisfactory shade and street tree. It is a very rapid grower and does extremely well in a great variety of soils and climates. In very dry soils the limbs are apt to be brittle and frequently split or break in wind storms, but this evil may be avoided by careful pruning and cutting back the lateral limbs which tends to strengthen the crotches. The foliage is dense, light and airy and always gives a graceful appearance. It is practically free from insect pests and diseases. The Soft Maple is a very valuable tree for wind-breaks, shelter-belts and wood-lot plantations. A small plantation of White Maple properly cared for would in a few years soon yield the owner a lot of valuable fire wood, or even lumber. This is easily propagated from seeds sown as soon as they are ripe in June or July.

A. S., var. Wierii laciniatum. Wier's Cut-leaved Maple. This is a horticultural variety of the common White Maple, differing from the species in having finely cut or dissected foliage and slender beautifully drooping branches. It is almost as hardy as the type, a very rapid grower and ranks among the most attractive of lawn trees. Good specimens have been seen in all parts of the state. It is propagated by budding or grafting the cut leaf form upon the common White Maple.

A. Saccharum, Marsh. Sugar Maple. Hard Maple. Native of southeastern Canada and eastern half of the United States. The specimens of Hard Maple show that while the tree is perfectly hardy, it is a rather slow grower under the conditions of Eastern Washington. Naturally the tree is tall and slender when grown with other trees but spreading when alone. It does not take favorably to dusty, smoky situations, so is not valuable in large cities, and from the na-

ture of its slow growth and thin foliage when young is not a popular street tree. Its foliage is very pretty any time, but especially so during the autumn when it colors up beautifully. The Hard Maple is easily transplanted but the stem should be protected from the sun for some time since it is apt to become "bound" or injured by scald. It propagates readily from seed planted as soon as ripe or stratified in sand and planted early in spring.

A. Spicatum, Mountain Maple. A small round topped tree to upright bush with thin foliage and slender branches. It makes a very slow growth on dry stony land but makes a very rapid growth on moist rich soil. Valuable only as a screen or low shade tree.

AESCULUS Glabra, Willd. Ohio Buckeye. Native of the eastern part of the United States. A small round topped, rather open-crowned tree, seldom growing more than thirty feet high. It is not so pretty in foliage flowers or shape as the Horse Chestnut, yet it is much prized for street, shade and specimen work in parks, lawns, etc. The flowers are more numerous than the following species. but smaller and of light yellow color. In moist locations in eastern Washington, it is a rapid grower and soon produces a pretty tree. It is easily transplanted when small and readily propagated from seeds.

A. Hippocastanum, Linn. Horse-chestnut. Native of southern Europe. A medium-sized to tall, round topped dense foliaged tree, having a very compact crown which causes it to be used extensively where a dense shade is desirable. It leaves out reasonably early in spring and is soon a mass of large beautiful spikes of white flowers. The wood of this tree has very little value commercially since it is soft and not durable. The Horse-chestnut is usually a slow grower during its first three or four years, but after it becomes established, in favorable soil it is a rapid grower, and makes splendid specimens for lawn shade or street planting. It is easily transplanted when young, and readily propagated either by planting the nuts as soon as ripe or stratifying them in sand and planting the following spring.

A. H., var. carnea. Hayne. Red Flowering Chestnut. A small dense foliage round topped tree bearing large red blossoms. Valuable for ornamental planting.

ALNUS Rubra, Bong. Red Alder. Native of western part of the United States and Canada. A large shrub or small round-headed tree, frequently attaining twenty-five feet in height. It is occasionally used for ornamental planting, and makes a very valuable plant for rich, moist or even wet ground. It is not desirable for dry situations.

AMELANCHIER alnifolia, Nutt. Juneberry, Shad-bush or Ser-

vice-berry. Native of practically all of the western half of the United States and southern Canada. A large shrub to small upright tree. If carefully pruned to one stem the June-berry makes a very pretty upright little tree which is one mass of beautiful white flowers in April or May and produces large quantities of fruit in June or July. In localities where fruit is scarce it is some times used as food, but ordinarily its chief value is to attract birds from other fruits. It is easily transplanted and readily propagated by suckers, root cuttings or seeds.

BETULA alba, Linn. European White Birch. Native of various parts of Europe and Asia. A very graceful little tree with white bark and slender branches. The foliage is light and airy and so produces very little shade, which makes it especially valuable for lawns, etc., where a grassy surface is desirable. It is perfectly hardy here and adapted to many kinds of soil, but readily responds to deep rich moist soil. The European Birch is not desirable for street planting but can be advantageously used in forest or wood lot plantations. While its wood is not valuable it is extensively used for furniture, fuel, etc. It is easily transplanted, rather hard to propagate, which is usually by seeds, but makes a rapid growth in favorable conditions.

B. a., var. pendula. Weeping White Birch. This is a horticultural variety of the preceding species which it resembles very closely but differs from it by having very slender pendulous branches. It is extensively used for lawn and park planting where the cut-leaved forms are too expensive. It is as hardy as the species and favors practically the same treatment.

B. a., var. laciniata. Cut-leaved Weeping Birch. This is another horticultural variety of the European White Birch, and is especially valuable for lawn and park planting on account of its finely divided leaves and drooping habit of its slender branches. It is considered by many to be the most beautiful of all lawn trees, and for this reason is commonly called "The Queen of Trees." Its tall slender stem and long, graceful branches make it very attractive to all. It is perfectly hardy here, but apt to be short-lived on dry soils. On deep rich moist soil it is long-lived and a rapid grower. It is easily transplanted, but difficult to propagate since it must be budded or grafted on common stocks.

B. lutea, Michx. Yellow Birch. Native of Newfoundland to North Carolina and Tennessee and then westward to Minnesota. A tall upright tree often attaining the height of one hundred feet. This is one of our most valuable forest trees for cool moist soils, but it cannot withstand drouth. The wood is hard, heavy, close grained and very valuable and is frequently termed American Mahogany.

It is easily transplanted and is a rapid grower in favorable soils, but not recommended for dry situations.

B. nigra, Linn. Red Birch. Native of the eastern part of the United States. A tall slender rapid growing tree with slender branches and dull green foliage. Valuable for wood and ornamental planting in moist places. Our dry southern slopes are too severe for it in eastern Washington.

B. populifolia, Ait. White Birch. Native of the eastern part of the United States. A small slender rapid growing tree with willowy branches and white trunk. A tree that prefers moist soil yet does very well on dry soil. Valuable here for wood and ornamental planting.

CARPINUS Caroliniana, Walt. American Hornbeam. Native of the eastern part of the United States westward to Minnesota and south to Texas and Mexico. A small bushy tree rarely attaining a height of forty feet, of an upright, compact nature with small attractive leaves and much desired for specimen trees in lawns and parks. The wood is very tough, heavy, fine grained and very strong. It is not a rapid grower but is easily transplanted and has done well wherever planted upon the campus and experimental plots. It is propagated by sowing the seeds as soon as they are ripe in the fall, but the germination is usually irhegular and unsatisfactory.

CATALPA bignonioides, Walt. Catalpa. Native of the southern states as far north as Tennessee. A very rapid growing round topped tree with large beautiful leaves, and many flowered pinacles of large showy flowers. It has the disadvantage of leaving out very late in the spring and losing its foliage very early in the fall, but in July its flowers in a measure make up for these disadvantages. It occasionally kills back a little here on the grounds but as a rule it may be safely used for ornamental planting. It is easily transplanted, and readily propagated from seeds planted early in th espring.

C. ovata, Don. Kaempfers Catalpa. Native of China and Japan. This is smaller and rather slower growing tree than either of the other forms. On the Station grounds it has proved itself hardy and worthy of a place for ornamental purposes. It leaves out late and loses its foliage early in the fall, but its blossoms are very attractive in July. It produces seed abundantly and may be readily propagated from seed sown in the spring.

C. speciosa, Wardner. Hardy Catalpa. A native of Illinois, Indiana and adjoining states. A tall upright growing tree often attaining one hundred or more feet in height. For protected situations this is a very valuable tree not only ornamentally but also for shade and forest purposes. In dry exposed situations it frequently kills back somewhat but quickly renews its growth the following

year. The wood is light, coarse grained and very durable when in contact with the soil, therefore making it especially valuable for fence posts and railroad ties. Its large leaves and attractive blossoms make it a general favorite for park planting. It is easily transplanted and a rapid grower when planted in moise rich soil. The Hard Catalpa is propagated from seed sown in the spring and occasionally from cuttings of mature wood. When used as a forest tree it should be permitted to grow at will for three or four years and then cut back to the ground with the idea of developing one strong straight stem, which will soon produce a fence post, railroad tie, or large pieces of fine wood. This practice may be repeated several times, or until the roots become diseased or die entirely.

CASTANEA Americana, Raf. American Chestnut. Native of the eastern part of the United States and south to Alabama and Mississippi. A tall, vigorous, upright growing tree often attaining ninety to one hundred feet in height. It is valuable for shade, ornamental and forest purposes. The wood is coarse grained and extensively used for furniture, railroad ties, posts, etc. Our specimens have made a fairly rapid growth and are very attractive. They have not matured nuts as yet. It is easily transplanted when young and rapidly propagated from the nuts planted as soon as they are ripe or stratified in sand and planted very early in the sphing.

C. crenata, Sieb. Japanese Chestnut. Native of China and Japan. A small tree or large shrub attaining a height of twenty to thirty feet. When left to grow naturally it produces an upright dense shrub which is very ornamental not only from the beauty of its foliage but also on account of the large upmber of burs borne in the top of the branches. It usually begins to bear nuts at six years of age and when the season is long enough produces a large crop of nuts which are fairly good both raw and for cooking purposes. It seems to be perfectly hardy and does real well when grown upon moist, rich soil. It is easily transplanted when young and is propagated by planting the nuts are soon as they are ripe or by stratifying and planting in the spring. As a small growing tree or large shrub, the Japanese Chestnut has few deciduous equals for ornamental planting. It leaves out early in the spring and retains its foliage late in fall. The foliage frequently colors some before dropping.

CELTIS occidentalis, Linn. Hackberry. Found native in various parts of the United States and Canada. A large rapid growing beautiful shade, lawn and park tree. It does best in moist, rich soil, but still makes a splendid growth on dry, poor soil. This tree is certainly a valuable substitute for the American Elm. Its beautiful foliage and slender graceful branches make it useful for ornamental

planting. The Hickberry is rather difficult to propagate. The seeds should be sown or stratified as soon as ripe.

CRATAEGUS coccinea, Linn. Scarlet Thorn. Native of eastern part of North America. A large round topped shrub or small tree with dark green, glossy leaves, and white blossoms nearly an inch across that appear in May. A very valuable plant for hedges, screens and specimen planting.

C. Crus-galli, Linn. Cockspur Thorn. Native of eastern United United States and Canada. A small spreading to round topped tree with dark green, glossy foliage and numerous long curved spines. This is one of the most striking trees of the Thorn family and is extensively used as an ornamental plant. It is a rapid grower and readily adapts itself to our conditions of soil and climate.

C. Douglasi, Lindl. Douglas Thorn. Native in parts of British Columbia, Washington, Oregon and California. A small round topped tree thirty to forty feet high, often having pendulous branches, which makes it a very ornamental plant for lawn or park planting. During the last of May or early in June it is covered with beautiful large bunches of pure white flowers and in autumn its fruit is very ornamental. Early in the fall its foliage takes a light yellow and later changes to a beautiful crimson color. Specimens or small groups of this plant are very valuable for park or lawn planting. It may be propagated by seeds which usually require two years to germinate, or by grafting or budding upon another Thorn or even a common apple stock.

C. mollis, Scheele. Smooth Thorn. Native of the eastern and central part of the United States and eastern Canada. A small rapid growing, round topped tree with dense dark green foliage and strong erect branches. Its blossoms in May and bright red fruit in September make it valuable for ornamental planting. Considered by many to be the best native thorn in America.

C. Oxyacantha, Linn. English Hawthorn. Native of Europe and Africa. A small, rapid growing, round topped tree, with beautiful dark green foliage. The great masses of pink and white blossoms which appear in May make this tree one of our most valuable ornamental plants. It requires one or two years to become established but after that it does very well, even on dry soil. A valuable plant for hedges, screens and ornamental planting.

C. pyracantha, Ait. Evergreen Thorn. . Native of Europe. A small irregularily topped evergreen tree with small dark green leaves, thorny branches and numerous red berries. A plant that starts into growth very slowly after being transplanted. Valuable for ornamental planting.

C. Piperi. Pipers' Thorn. Native of western United States. A

small, dense, round topped tree, with dark green foliage, abundance of white blossoms in May and bright red fruit in August. Useful for ornamental planting.

ELAEGNUS augustifolia, Lin. Russian Wild Olive or Oleaster. Native of Southern Europe and Western Asia. A hardy, small, rapid growing, round topped tree or large shrub with long silvery gray leaves. It leaves out early in the spring, produces a lot of small, yellow, fragrant blossoms the last of June and holds its leaves late into the winter. It is particularly adapted to our long, dry, dusty summers, is valuable for shade, ornamental planting and hedges and is one of the few ornamental trees that will thrive in strong alkali soil. When used as a hedge plant, the constant shearing and clipping develops an unusual number of sharp thorns making it a barrier that will turn stock of all kinds. The Wild Olive, as it is commonly called, is readily propagated from seeds and transplants very easily, if taken before it is more than four years old.

FAGUS sylvatica, Linn. European Beech. Native of central and Southern Europe. A medium sized, upright tree, with feathery limbs and silky foliage. One of the most beautiful ornamental trees but very difficult to transplant after it has passed its seeding stage. It forms a very strong tap root with few laterals thus making it almost impossible to transplant large trees that have never been reset before. All Beeches should be severely pruned and little top growth expected before the second or third year after being transplanted.

F. heterophylla. Loud. Fern-leaved Beech. A horticultural form with a dense, compact top, cut leaves and tendril-like branches. Valuable for planting on north slopes in moist soils or protected situations but of little value in exposed places in eastern Washington.

F. purpurea, Ait. Purple Beech. A purple form of the European Beech grown for its beautiful dark purple foliage. Our specimens have made a splendid growth during the past years and while usually considered tender, yet they appear to be hardy enough for this climate. Very difficult to transplant except when young.

FRAXINUS Americana, Linn. White Ash. Native from Canada to Florida and west to Minnesota and Texas. The White Ash, if well grown, is one of our most valuable as well as ornamental trees. It is large, often one hundred and twenty feet high, round topped, dense foliaged, and well branched. It is used extensively for shade, wind-break and wood lot planting. The wood is valuable and durable. Under normal conditions the tree is perfectly hardy, easily transplanted and a rapid grower. It is ocassionally troubled with ash aphis but may be easily freed by proper spraying. It is easily propagated by planting seed in the fall or keeping dry and planting in spring.

F. excelsior, Linn. English Ash. Native of Europe and Asia. A large rapid growing, upright tree with dark green foliage and strong, erect limbs. Valuable as a shade tree in moist soil but of little value in hard dry soils. It requires severe pruning when young to get the best results. Propagated from seed sown as soon as ripe or stratified and sown early the next spring.

F. lanceolata, Borkh. Green Ash. Native from Maine to Florida and west to the Rocky Mountains. A medium sized, round topped tree, often attaining a height of sixty feet or more. It is very desirable for its wood which is hard and strong but coarse grained and brittle. Valuable for shade and street planting since it stands neglect and drouth remarkably well and is extremely hardy, but has the habit of starting into growth early enough each spring to get caught occasionally by a late spring frost and is subject to bad attacks of green aphis. Under favorable conditions of soil and moisture the Green Ash is easily transplanted and makes a rapid growth. It is easily propagated by planting the seeds in the fall or keeping them until spring and then plant. The seedlings of the Green Ash vary much the same as other seedlings. So, by a little care in selection, it is possible to secure a wide variation in color as well as the time of falling of the foliage.

F. nigra, Marsh. Black Ash. Native of the central parts of the United States. A small, slow growing tree, with gray green leaves. While it does fairly well on moist soil, yet it is of no value for this state.

F. Oregona, Nutt. Oregon Ash. The Oregon Ash is purely a western tree, being native of parts of Oregon and California. It is a round topped, strongly branched tree, with smooth gray bark, attaining a height of from seventy to eighty feet. Under favorable conditions of soil and climate the Oregon Ash makes a nice shade tree, produces a fair quality of wood and is easily transplanted. The hard freezes of March 10, 11, 12, '06, killed this back severely in eastern Washington. So for this reason we cannot recommend it as being perfectly hardy. It may be easily propagated from seeds sown in fall or spring, which come the first year after planting.

F. Ornus, Linn. Flowering Ash. A native of Southern Europe and western Asia. The Flowering Ash is a medium sized, round topped to conical shaped tree, with beautiful dense foliage, compact upright branches, firm heavy crotches, which seldom or ever split or break in the winds, and a smooth gray green trunk. It is one of our most ornamental and attractive trees which may be used for street, wood lot or shade planting. It is free from insect pests and fungus diseases and so gives us a very clean tree. Under favorable conditions it is easily transplanted, a rapid grower, and readily pro-

pagated from seeds which usually require two years to germinate. It starts into growth late in spring and thereby is seldom caught by the late frosts. It is perfectly hardy on the station grounds. The Flowering Ash should be extensively planted not only on account of its beauty but also for its wood producing tendencies.

F. quadrangulata, Michx. Blue Ash. Native of the central part of the United States. A large upright growing tree with dense foliage and corky branches. It requires moist soil to secure the best results. Not valuable in this state.

GINKO biloba, Linn. Maidenhair Tree. A native of northern China which was introduced into the United States almost a century ago, and has now become a very popular tree where the climate is not too severe. It is a tall, slender, thinly branched, upright growing tree extensively used for ornamental planting. While it has not been planted in large numbers in the state, yet beautiful specimens are frequently seen. The Maidenhair Tree is easily transplanted and naturally prefers a moist, rich soil, but does remarkably well on dry soil. It is usually propagated from seed stratified as soon as ripe in the fall and then planted in the spring.

GYMNOCLADUS Canadensis, Lam. Coffeetree, Kentucky Coffee Tree. Native of the south central part of the United States. A very rare forest tree of irregular form. One is usually attracted by its oddness rather than beauty. Its bare, peculiar limbs in winter, its rich brown leaves, which appear so late in spring, and the large brown pods each add to its attractiveness. While our specimens have made a tall growth they contain but few lateral branches. It seems to be perfectly hardy. The Coffeetree is propagated from seeds which should be scalded before planting.

HICORIA laciniosa, Sarg. Big Shell-bark Hickory. Native of the central and southeast part of the United States. A large growing tree with dull green foliage and strong branches. A tree that starts to grow very slowly but does well on moist rich ground.

H. minimia, Britt. Bitter Nut. Native of eastern United States and Canada. A large upright broad topped tree with dense foliage and strong branches. It grows very rapidly in moist soils and responds readily to cultivation and irrigation. A valuable tree for shade, forest and ornamental planting. Propagated from nuts planted as soon as ripe or stratified and planted as early as possible the next spring.

H. Pecan, Britt. Pecan Nut. Native of central and eastern part of the United States. A tall upright growing forest tree when young, but spreading and irregular when old. Not a rapid grower with us but a valuable forest tree in many ways. Propagated by planting nuts or budding on seedlings.

JUGLANS cinerea, Linn. Butternut. Native of New Brunswick to Georgia, west to South Dakota and Arkansas. A tall, lofty tree when grown in forest conditions, but large, spreading, round topped tree when grown in the open. It leaves out late in spring, but has pretty dense foliage in the summer time which is practically free from insects and plant diseases. The wood is light, rather soft, coarse grained and not nearly so valuable as the Black Walnut. It should be planted extensively not only for its wood and ornamental values but also for the nuts it produces. On rich moist soil it is a rapid grower, produces large crops of nuts, and is easily transplanted. It is propagated practically the same as the Black Walnut.

J. Mandschurica, Maxin. Mandschurian Walnut. Native of eastern Asia. A valuable nut and wood producing tree for the irrigated valleys but not hardy enough for the uplands of eastern Washington. The trees always make a strong growth each year at the Station and winter kill from one-half to two-thirds of the new wood each year.

J. nigra, Linn. Black Walnut. Native of Massachusetts to Florida, west to Minnesota and Texas. A tall upright tree, often attaining one hundred and fifty feet in height when grown under forest conditions but when grown in the open it is spreading or even round topped. The foliage appears late in the spring and is dense and beautiful. The wood is hard and strong and considered one of our most valuable woods. The tree is practically free from insects but is occasionally slightly affected with walnut anthrocnose which fortunately does very little damage here in Washington. Under favorable conditions of moisture and rich soil it is easily transplanted and makes a rapid growth. It is sometimes difficult and expensive to transplant successfully old walnut trees which have never had tap roots cut, but most nursery men are now prepared to supply their customers with trees that have well branched roots thus making transplanting easy. One of our most valuable shade trees.

J. regia, The Persian or English Walnut. Native of southern Europe and Asia. A very valuable shade and nut producing tree in many parts of the state. And while hardy enough to grow anywhere in the state, yet some sections are too severe for it to become of value as a nut producing tree. In Eastern Washington it winter kills when young, but does well after becoming thoroughly established. None but the hardiest sorts such as Mayette and Franquette varieties should be planted. The walnuts are easily transplanted when young, readily grown from nuts but difficult to bud or graft.

J. Sieboldiana Maxin. Japanese Walnut. Native of eastern Asia. This species has made splendid growth in our plots and while tender when young it soon becomes hardy enough to stand our winters. Like

the English and Mandschurian Walnuts, it does very well in the irrigated valleys and Western Washington.

Walnuts are easily propagated by gathering the nuts in fall and either planting at once or stratifying in sand and then planting the following spring.

LIRIODENDRON Tulipifera, Linn. Tulip Tree. Native of central and eastern parts of the United States. A large rapid growing tree with beautiful lobed leaves and large greenish yellow tulip like flowers. One of the most beautiful lawn and park trees in America. It is very difficult to transplant and should be attempted only when small. The Tulip Tree requires deep moist soil for its best development and should not be expected to grow on very dry soil. Our specimens on a northern slope have made splendid growths while those on southern or western slopes have practically all failed. It starts into growth very slowly but after once becoming established makes very rapid growth. Where proper conditions exist it is a very valuable forest tree. Not generally valuable except on northern slopes in eastern Washington.

MORUS alba, Linn. White Mulberry or Russian Mulberry. A small round topped tree that was introduced into the central states by the Russian Mennonites, who made use of it as a fruit, a hedge plant, and when the wood attained sufficient size, for fuel. It is very rapid in its growth, but occasionally kills back during our late spring frosts. Some individual trees bear fairly edible fruit but it is usually considered worthless where so much better fruit may be grown. The Russian Mulberry is used for ornamental planting and windbreak purposes, but is not at all adapted to our dry southern slopes.

PLATANUS occidentalis, Linn. Sycamore, American Plane Tree. A native of Maine to Minnesota and south to Florida and Texas. A large round topped or broad headed tree from one hundred and fifty to one hundred and seventy-five feet high. It is very valuable for shade, street and park planting, being especially ornamental and attractive on account of its silver gray leaves. It is easily transplanted makes a rapid growth in moist soil and is readily propagated from seed sown in spring after being kept moist during winter, or from cuttings or ripe or green wood.

POPULUS alba, Linn. White Poplar, Silver Poplar or erroneously called Silver Maple. Native of Europe and Asia. A very pretty round topped spreading tree, attaining large size in a comparatively short time. On account of its very rapid growth is valuable for shade, street and wood lot planting. It is perfectly hardy and under normal conditions of moisture and fertility produces good sized boles and considerable branch wood in a few years. It should not be planted too extensively, however, on lawns or in parks since it tends to

cheapen the effect, although a few trees may be advantageously used to lighten up the more sombre clumps. The wood is light, soft, close grained and, if properly cured, makes a good fuel. It is easily propagated from hardwood cuttings or by digging the suckers which spring up abundantly around the trunks of old trees. The trouble these suckers cause may be helped somewhat by carefully pulling them out instead of cutting as is usually the case.

P. a., var. Bolleana, Lauch. Bolles Poplar. A varietal form of the common White Poplar, resembling the Lombardy Poplar in habit and growth. Its upright growth gives it a very striking appearance and makes it especially valuable for mixed planting in small numbers on lawns, in parks, etc. It does not sucker so freely from the roots as most Poplars but it occasionally sends up a sprout. It may be propagated from mature hardwood cuttings.

P. balsamifera, Linn. Balsam Poplar. A native of northern United States and southern Canada. A large upright growing tree which is very useful for shade, hedge and wood lot purposes.

From the nature of its rapid growth, its ability to withstand drouth and severe winters it becomes one of our valuable but short-lived trees. While it does fairly well on dry, poor, soil, yet it does real well on rich, moist soils. It is easily propagated from hardwood cuttings and readily transplanted either as large or small trees.

P. b., var. candicans, Gray. Balm of Gilead. Native from New Brunswick to Minnesota. A large strong growing round topped tree often attaining one hundred or more feet in height. As a quick growing tree it is especially valuable for wood lot purposes and may occasionally be used for street trees. It is probably the best of the Poplar for shade purposes, but has the undesirable feature of occasionally losing its top in wind storms or at least becoming unsightly and also suckering freely in the lawn. It stands drouth fairly well but does not take kindly to dust and smoke of city life. The wood is fine grained, soft and not very strong. Its vigorous growth and pleasant odor given off by the buds make it a general favorite. The Balm of Gilead is easily propagated from cuttings of mature wood or suckers planted any time when the leaves are off the tree.

P. Caroliensis, Hort. Carolina Poplar. A large rapid growing upright form of the Cottonwood with large dark green leaves and strong, erect branches. This tree is taking the place of the Lombardy Poplar as well as the common Cottonwood to a large extent in the new plantations that are now being made in many parts of the country. It is a superior tree in every way not only on account of its rapid growth but because it never gives off any cotton so troublesome with tree cottonwood. It is easily propagated from cuttings

taken when the tree is dormant and grows better in dry soil than any other Cottonwood.

P. deltoides, Marsh. Cottonwood. Native of Quebec, Rocky Mountains and South. A very large round headed, much branched tree frequently attaining one hundred or more feet in height. It is valuable for shade, ornamental, forest and wind-break purposes. The wood is light, spongy, weak and soon decays when in contact with the soil. Its ability to withstand severe winters and dry summers has caused it to be used entirely too much. Many cities are now passing ordinances against the use of this tree for street purposes on account of it giving off so much cotton at seeding time. However, this difficulty may be avoided by propagating from the staminate sort. It is readily propagated from cuttings taken any time during the dormant period and either planted at once or stored until early spring.

P. laurifolia, Ledeb. Russian Poplar. Native of Europe and Asia. A short-lived rather large upright growing tree very useful for wind-break and wood lot purposes. Its upright habit renders it unserviceable for street or shade purposes. The specimens on the campus have made a rapid growth and shown a wonderful resistance to drouth which makes it an especially valuable tree for general wind-break planting. It has the tendency of producing a large, tapering trunk. It may be readily grown from cuttings or suckers which spring up abundantly around old trees.

P. nigra, var., Italica, Du Roi. Lombary Poplar. A tall columnar growing tree brought to this country from Asia. A tree that might well be called the "Missionary of Trees," since it is usually always used as a forerunner of better and more permanent varieties. It is liked on account of its rapid growth, ability to withstand severe weather, both cold and dry, and the rapidity with which it forms a large amount of wood. The wood is light, soft, not strong, and can be used for about the same purposes as Cottonwood. The Lombardy Poplar is usually a short-lived tree or at least soon becomes ragged at the top. This can be helped, however, by an occasional severe cutting back which in a measure rejuvenates the tree and lengthens its life. Too much has been expected of this tree and consequently it has been over planted in a few sections of the state. Its particular value lies in its quick growth, making it suitable for wind-break and wood lot plantations, but it should never be used as a shade or street tree, and sparingly used in ornamental planting. It is readily propagated from hardwood cuttings or by suckers from the roots.

P. tremula, Linn. European Aspen. Native of Europe and Asia. A medium sized, open topped tree with small leaves attached to long

slender petioles which causes the constant quivering so common in the Aspen tree. It is a valuable little tree for shade, ornamental planting in moist, or even wet soils, but is of little value in dry soils. Propagated easily from cuttings or root sprouts.

P. t., var., pendula, Hort. An attractive weeping form of the European Aspen. Grows well in dry soil, but prefers moist or even wet soil. Propagated from cuttings taken when the tree is dormant.

P. tremuloides, Michx. American Aspen. Native in some of its forms of practically all parts of the United States. A small rapid growing tree when young, but slow growing when old; seldom attaining more than fifty or sixty feet in height. Like the Birch it is always ready to follow the forest fire or lumberman's ax. Its smooth greenish white bark, pendulous limbs, ever quivering leaves and beautiful autumn coloration of its foliage make it a general favorite for planting in a limited way on lawns, parks, etc. In moist rich soil it is a rapid grower and does fairly well even on dry soil. The wood is light, soft and fine grained. Its principal use is for paper pulp. The Aspen is readily propagated from hardwood cuttings and by the use of suckers which spring up abundantly.

P. trichocarpa, Hook. Black Cottonwood. Native of western United States. A very large broad open topped tree with large straight bole and horizontal branches. The lumber is valuable for paper pulp, thin box material and other domestic purposes. It grows rapidly in moist soil and is valuable for wind-breaks and forest planting.

PRUNUS Americana, Marsh. American Wild Plum. Native of the central parts of the United States. A small round topped tree with slender branches and numerous thorns. It grows well in dry soil but prefers moist or even wet soil for its best development. Its numerous white blossoms in May, hardy nature, and red and yellow edible fruit in September make it valuable as a hedge plant, small shade tree and ornamental plant. It is easily transplanted and may be propagated from root cuttings or seeds.

P. avium, Linn. Mazzard Cherry. Native of Europe and Asia. A tall rapid growing tree with erect branches and dark green foliage, usually used as a stock for sweet cherries but of value as an ornamental and forest tree. Its beautiful now white blossoms in May and abundance of ripe fruit in July makes it doubly attractive for park and shade tree planting. It is easily propagated from seeds and readily transplanted.

P. cerasifera, Ehrh, Myrabalan Plum. Native of Europe. A small shrubby tree with erect branches and dark green foliage, usually used as a stock upon which to bud known varieties of the common plum. Valuable as a hedge plant, small shade tree or low screen.

It makes a rapid growth in almost any kind of soil and is easily transplanted.

P. c., Pissardi, Hort. Purple-leaved Plum. A very attractive form of the preceding species with dark reddish purple foliage and dark wine red fruits. It is one of our best purple-leaved trees and seems to adapt itself to all kinds of conditions. Valuable for lawn and park planting only where individual trees are desired.

P. Cerasus, Linn. Sour Cherry. Native of Europe. A small round headed tree with willowy branches and dark green foliage. While ordinarily used as a fruit tree yet it has splendid ornamental values as a specimen tree or small shade tree for lawn or park planting. It is easily propagated from seed planted as soon as ripe or stratified and planted early in spring, but has the undesirable habit of suckering quite freely.

P. Mahaleb, Linn. Mahaleb Cherry. Native of Europe. A small round topped tree with slender horizontal branches and small dark green leaves. Its ability to grow in hard, dry soils, early white blossoms and general spreading habit make it of value for ornamental planting especially where thin shade is desirable.

P. Pennsylvanica, Linn. Bird or Pin Cherry. Native of many parts of the United States. A small rapid growing tree with willowy branches and light green foliage. The small bunches of white blossoms appear in May and the fruit ripens in September. It is readily propagated from seeds and thrives in almost any soil but prefers moist or even wet soil. It has the undesirable habit of suckering quite freely.

P. Padus, Linn. European Bird Cherry. Native of Europe and Asia. A small erect growing tree resembling in many ways the common Choke Cherry. Its very early leafing and blooming habits make it desirable as an ornamental plant. It is a rapid grower and does well on almost any kind of soil and is easily transplanted.

P. P., var., fl. pl. Hort. Double Flowering Cherry. A horticultural variety of the Bird Cherry with large double white flowers making it especially valuable for ornamental planting. Apparently hardy here, a rapid grower and one that does well on almost any kind of soil.

P. Persica, fl. pl. Hort. Double Flowering Peach. A rapid growing double flowering form of the common peach. Valuable as an ornamental plant for all kinds of lawn or park planting. Propagated by budding the seedlings of the peach.

P. serotina, Ehrh. Wild Black Cherry. Native from Nova Scotia to South Dakota and south to Florida and Texas. A tall, large, straight or sometimes spreading tree, frequently attaining one hundred feet or more in height. This is one of our valuable timber,

shade, street and park trees. The wood is light, strong and rather hard, of reddish brown color and takes on a beautiful satin finish, which makes it especially valuable for cabinet making and interior work and for school apparatus, etc. The Wild Black Cherry is a general favorite as a specimen tree on account of its dark glossy foliage which remains late on the tree in the fall. Its numerous clusters of beautiful white flowers which come out in May and its attractive red and black fruit which frequently cling to the tree until November make it very ornamental for lawn and park planting. It is propagated from seeds which must be planted as soon as they are picked or stratified in sand until spring and then planted.

P. spinosa, Linn. Black Thorn. Native of various parts of Europe, Asia and Africa. This large bush or small tree is frequently cultivated as a hedge plant or a small ornamental tree. It is especially attractive in May when in full bloom and during the fall when its fruit is of bluish purple color. The Blackthorn is a bad sprouter and when planted on a lawn frequently gives serious trouble to the lawn mower. It is perfectly hardy and may readily be propagated from its pits or by digging the suckers.

P. Virginiana, Linn. Choke Cherry. Native of practically all parts of the United States. It varies from a bush to a round topped upright tree thirty or more feet in height. It is highly ornamental when in bloom in May and can be advantageously used when a small shade tree is desired. It usually bears a large crop of small black cherries which add to its beauty in the fall. It has the undesirable features of suckering freely, which interferes with the lawn. The wood is heavy, close grained, and light colored. It is a very desirable plant for low wind-breaks and shade in poultry yards. The Choke Cherry is easily propagated from seed or suckers and one experiences no difficulty in transplanting.

PYRUS Baccata, Linn. Siberian Crab. Native of eastern Asia. A very hardy round topped tree with dense foliage and numerous white blossoms which appear early in May. Its rapid growth, ability to grow in all kinds of soils and climates and fresh appearance make it a very valuable tree for general ornamental planting in all parts of the state.

P. coronara, Linn. Wild Crab Apple. Native of the central and eastern part of the United States and Canada. A small thorny tree with stiff branches and dark green leaves and beautiful rose red blossoms which appear in May. It grows well on all kinds of soils but prefers rich moist for the best development, is easily transplanted and readily propagated from seed.

P. floribunda, Nicols. Flowering Crab. Native of Japan. A small tree or large bush with dark green foliage and slender wil-

lowy branches. Early in May this plant is one mass of pink and white blossoms and in the fall covered with bright yellow fruits about the size of a pea. It grows in almost any kind of soil and readily adapts itself to our varied conditions. One of our most valuable ornamental trees.

P. f. Scheideckeri Hort. Scheidecker's Crab. A dwarf double flowered horticultural form of the Flowering Crab, having a dark pink blossom appearing very early in spring. It is hardy, does well in our climate and is very ornamental as a flowering plant.

P. fusca, Raf. Oregon Crab. Native of western United States and Canada. A medium sized tree with small gray green leaves and thorny branches. A useful plant for moist soils but of slow growth in dry hard soil.

P. Soulardi, Bailey, Soulard Crab. A natural hybrid of two of our American crabs. A strong growing round topped tree with erect branches and dark green foliage. Its hardy nature, numerous pink blossoms and ability to grow in all kinds of soil make it a valuable plant to use in many ways.

P. toringo, Sieb. Dwarf Crab. Native of Japan. Small spreading tree or large shrub with pink blossoms and fruit the size of a pea. A rapid grower on moist soil but slow and unsatisfactiry on hard or dry soil. Useful for ornamental planting.

QUERCUS alba, Linn. White Oak. Native of the eastern part of the United States. Under favorable conditions of soil and moisture this is one of the best timber trees, but on dry soil the White Oak has not been a decided success in our tree plots. Its slow growth and occasional killing back makes it unsuitable for permanent plantings. However, under other conditions, it may prove a favorable tree for planting.

Q. coccinea, Muench. Scarlet Oak. Native of the eastern portion of the United States. A large growing tree with gradually spreading limbs, valuable for shade, ornamental and wood lot planting. The wood is strong, heavy and coarse grained and excellent for fence posts, finishing lumber, etc. The Scarlet Oak has made a very rapid growth and is the most beautiful autumn coloring tree on the grounds. It grows best in moist rich soil but can be grown very successfully on drier soil. A few specimens should be planted in all large collections to give the autumn coloring. It is easily propagated from acorns planted in the fall as soon as they are ripe or by stratifying and planting early in the spring.

Q. ilicifolia, Wangh. Scrub Oak. Native of the eastern part of the United States. A small rapid growing shrubby tree with dull green foliage. Adapted to dry rocky situations and useful only as a screen or cover for hillsides or steep banks.

Q. cuneata, Wangh. Spanish Oak. Native of the southeastern part of the United States. A rapid growing, medium sized, upright to round topped tree with beautiful dull green foliage becoming bronzy brown early in the fall. It grows well in dry soil but prefers the rich moist soil for the best results. One of our best Oaks. Valuable for ornamental as well as forest planting.

Q. imbricaria, Michx. Shingle Oak. Native of the southeast and central parts of the United States. A medium sized to pyramidal topped tree with beautiful dark green glossy foliage which turns red in the fall. Its symmetry when young and glossy foliage makes it valuable for ornamental planting, especially where the soil is moist.

Q. rubra. Linn. Red Oak. Native of the eastern part of the United States and Canada. A large rapid growing round topped tree with dull green foliage which turns red in the fall. Grows well in almost any kind of soil but prefers the moist soil for best development. Valuable for forest as well as shade planting.

Q. macrocarpa, Michx. Bur Oak. Native of the eastern and central United States and eastern Canada. A large spreading tree with dense dark green foliage and coarse corky branches. Of rapid growth on moist soil but slow and poor on dry hard soil. A valuable tree for forest shade and ornamental planting.

Q. palustris, Linn. Pin Oak. Native of eastern and central United States. A medium sized pyramidal to irregular topped tree with dense beautiful foliage which colors bright red in the fall. Grows well on dry soil but prefers moist for its best development. Useful for shade or ornamental planting.

Q. prinus, Linn. Chestnut Oak. Native of the eastern part of the United States and Canada. A large, upright, irregular shaped top tree, often seventy and occasionally one hundred feet high. The Chestnut Oak has made a very rapid growth with us and appears to withstand drouth remarkably well. In the fall its foliage colors up very prettily, making it especially valuable for lawn and park planting. The wood is very valuable for all purposes requiring strength and lasting powers.

Q. sessiliflora, Salieb. English Oak. Native of Europe and western part of Asia. In its native country under forest conditions it is a large, upright, irregular topped tree with stout spreading lateral branches. In our plots and on the campus it has become very popular on account of its rapid growth, very pretty foliage, which frequently remains on until spring, and low branching habit, making it an ideal tree for specimen as well as group planting. It appears to be hardy and has made very satisfactory growth upon dry soils as well as on moist or rich soil. By careful pruning it can be made to take on a beautiful tree form and to branch from the ground

up to the top. It is propagated by either planting the acorns as soon as they are ripe in the fall or by stratifying them in moist sand and planting very early in the spring.

Q. velutina, Lam. Black Oak. Native of the central and eastern part of the United States. A large rapid growing upright tree with slender branches and dark green foliage which turns brown in the fall. It does well on dry soils and makes a valuable tree for general planting.

ROBINIA Pseudacacia, Linn. Black Locust, Yellow Locust or Locust. Native of the eastern part of the United States. A tall slender upright growing tree with light attractive foliage and fragrant white or purple blossoms which hang in long racemes in May or June. One of our most valuable shade and wood lot trees since it is a very rapid grower, withstands severe drouth and is almost if not perfectly hardy. The wood is hard, fine grained and very heavy. It is valuable for fuel, fence posts, etc. The Black Locust is easily propagated by seeds or by removing sprouts which spring up so readily near the old trees. The seeds should be gathered in the fall or winter and kept dry until the following spring. When the soil is ready soak the seeds in hot water, this will cause most of them to swell to several times their natural size. These should be sifted or picked out and the remainder soaked again in hot water. This process of scalding should be continued until all have started to swell; then the seed may be planted in rows much the same as peas, and by fall they will have grown into nice little trees. One of its disadvantages is that the seed pods remain on the tree the year around and make it rather unsightly during the spring and early summer.

SALIX alba, Linn. White Willow. Native of the northern part of Europe and Asia. A large rapid growing tree with short trunk and many lateral branches. It may profitably be used as an ornamental plant where a quick growth is desired or as a nurse tree, but its chief value is in its use as a wind-break or wood lot tree. In moist rich land it produces large quantities of valuable fuel, provided it is cured under cover. The White Willow is easily propagated from cuttings planted either in the fall after the leaves have fallen or in the spring before growth is resumed.

S. Babylonica dolorosa, Rowen. Wisconsin Weeping Willow. A horticultural variety of the Napoleon Willow with long slender, pendulous branches and beautiful glossy foliage. Under favorable conditions of soil and moisture it makes a very pretty tree but it is not perfectly hardy since an occasional winter will kill it back at least to the main stem. It is easily propagated from cuttings.

S. blanda. Smooth Willow. Native of Europe. A large rapid growing tree with thick trunk and numerous branches. Useful in

wind-breaks, wood lot plantings and as an ornamental plant. Especially valuable where quick growth is desired.

S. cordata, Muhl. Diamond Willow. Native of many parts of North America. A small shrubby tree with short trunk and rigid branches. Of very little value in this country.

S. discolor, Muhl. Pussy Willow. Native of eastern North America. A small rapid growing shrubby tree. Worthy of cultivation. Valuable in dry as well as moist soil.

S. elegantissima, Koch. Thurlows Weeping Willow. Native of Japan. A beautiful slender growing weeping tree with gray green foliage and light willowy branches. One of our hardiest and most rapid growing weeping trees. It is easily propagated from cuttings taken while the tree is dormant.

S. lucida, Muhl. Glossy Willow. Native of eastern North America. A low rapid growing bushy tree with brown branches and dark green glossy foliage. Very attractive as an ornamental plant.

S. nigra, Marshall. Black Willow. Native of eastern North America. A small rapid growing tree rarely used ornamentally but of value for fuel purposes.

S. pentrandra. Linn. Laurel-leaf Willow. Native of Europe and Asia. A small tree or large bush eight to twenty feet high. The leaves are of dark green color and very glossy, making it attractive as a lawn or park plant. The twigs are of a dark reddish brown color and also glossy. The Laurel-leaf Willow is not especially valuable for wood purposes but may be used as a hedge or wind-break. It is easily propagated from cuttings.

S. sericea, Marsh. Silky Willow. Native of eastern part of North America. A small spreading tree with silky leaves. Valuable only as an ornamental plant.

S. viminalis, Linn. Osier Willow. Native of Europe and Asia. A very rapid growing plant with long slender branches. When cut annually these shoots are from five to six feet in length and very slender indicating value for basket purposes.

S. vittellina, Linn. Golden Willow. Native of various parts of the United States. A large round topped tree with a thick short trunk. It is valuable for shade, wind-breaks, hedges and wood lot purposes, but especially useful for ornamental planting where a winter effect is desirable. As a hedge plant it survives severe pruning remarkably well. The bright golden yellow of its young branches produces a striking contrast to the dull gray or brown twigs of numerous other trees and shrubs. The Golden Willow grows fairly well on dry land but makes the best growth upon moist rich soil. It is easily propagated from cuttings.

SORBUS Americana, Marsh. American Mountain Ash. Native of the north and eastern parts of the United States. A rapid growing small tree to large shrub, occasionally attaining thirty or more feet in height. By careful pruning it may be trained to a single stem, but our most attractive and best specimens are composed of from five to seven stems pruned to umbrella form. The foliage is dark green and beautiful. The flowers are very showy the latter part of May or early in June, and the fruit makes it a general favorite from July until October. The American Mountain Ash is very valuable as an ornamental tree for lawn and park planting and the seedling are now occasionally being used to graft apples upon instead of apple stocks. It is easily grown from seed gathered and cleaned in the fall and stratified until the second spring as very few seeds will germinate the first year after maturing.

S. aucuparia, Linn. European Mountain Ash. Native of Europe and Asia. A small rapid growing round headed tree from forty to sixty feet high somewhat resembling the American Mountain Ash but usually retaining its leaves and fruit later in the season. The European Mountain Ash is especially ornamental and may be profitably used where a small tree is desired. Its flowers in May and June, beautiful light green foliage and bright red fruit all add to its charms. It is propagated in the same manner as the American Mountain Ash.

S. sambucifolia, Roem. Western Mountain Ash. Native from Labrador to Alaska and south to Pennsylvania to Michigan. Also found in Europe and Asia. A very attractive small tree or large shrub from twenty to thirty feet high. It is adapted for ornamental planting when a small tree is desirable. The large clusters of white flowers and bright red berries of autumn make it a general favorite.

S. hybrida, Linn. Oak-leaved Mountain Ash. A European hybrid of two forms found in that country. It is a small compact upright tree often attaining thirty or more feet in height. In our plots it has made a rapid growth, appears perfectly hardy and withstands drouth remarkably well. The Oak-leaved Mountain Ash may be used the same as the other forms of this group.

TILIA Americana, Linn. Basswood or American Linden. Native of the eastern part of North America. A medium to large round topped tree with beautiful light green foliage and fragrant blossoms which appear early in June. Its rapid growth, freedom from pests, fragrant flowers and ability to adapt itself to natural conditions make it one of our most useful shade and forest trees.

T. heterophylla, Vent. Native of eastern part of the United States. A large rapid growing tree with light green leaves and fragrant flowers. This tree resembles the American Basswood, but is

of a more rapid growth and has larger leaves. Useful for shade and ornamental planting.

T. vulgaris, Hayne. .European Linden, European Basswood. Native of northern Europe. Under forest conditions it develops into a large round topped tree often ninety or more feet in height. On the campus and in our tree plots it is one of our most attractive trees. Its compact conical form when grown as a specimen with limbs to the ground, or the dense round topped tree when pruned up is always admired. The leaves are showy and remain on long after most other trees have lost their leaves. When in blossom it is very fragrant and valuable as a honey plant. While not especially valuable as a wood producing tree, yet as a small shade tree or a beautiful lawn specimen it has few equals. It is rather difficult to propagate since it requires two years to get the seed to germinate, but it may be grown from layers or even cuttings of the young wood if they are carefully calloused before planting.

ULMUS Americana, Linn. White Elm, American Elm. Native of practically all parts of the United States east of the Rocky Mountains. A tall usually upright but variable tree, often attaining one hundred and twenty feet or more in height in forest conditions. A collection of American Elms usually show a wide range of forms from stiff upright "Vase" form to the beautiful "Feathery Fringed" or "Pendulous" forms. In moist places the American Elm is a very valuable shade, ornamental and forest tree, but from our experiments it does not appear to be adapted to our soil and conditions on account of being so seriously molested by plant aphis. Our specimens have made a fair growth and in most ways valuable. It may be propagated from seeds sown as soon as they are ripe which is usually the early part of June.

U. racemosa, Thomas. Cork Elm, Rock Elm. Native of northeastern and central portions of the United States. A large, oblong to round topped tree, often attaining eighty to one hundred feet in height. Usually not so rapid a grower as the American Elm but nevertheless a valuable tree for Washington. Our specimens are small but very fine, clean rapid growing trees. The peculiar corky wings on the young limbs make this tree especially attractive in winter. The Cork Elm transplants easily and is readily propagated from seeds sown as soon as they are ripe.

U. scabra, Mill. Scotch Elm. Native of Europe and Asia. A large upright tree often growing one hundred or more feet in height. It is almost as variable as the American Elm in form and even more so in color of foliage. The Scotch Elm is especially valuable in Washington as a shade and ornamental tree. Our specimens have made a very rapid, healthy, clean growth and thus far have been

practically free from all forms of insect pests so common to the American Elm. The leaves of this tree are especially attractive, being large dark green and very rugose. It is easily propagated from seed sown soon as they are ripe.

EVERGREENS

ABIES balsamea, Mill. Balsam Fir. Native of the northeastern part of the United States and the eastern part of Canada. Under favorable conditions this is a tall slender tree with short horizontal branches. It does not appear to do as well in the West as it does in the East, yet is is possible to grow beautiful specimens here. On moist rich soil it makes a rapid growth producing a very attractive lawn tree, while on dry soil it is slow and occasionally produces an unsightly, scrubby looking tree. The Balsam Fir varies in color from a dark green to a silvery white. In ornamental planting one usually desires the silvery specimens.

A. grandis, Lindl. Native of the western part of the United States and British Columbia. A very tall slender growing forest tree frequently attaining three hundred feet in height and logs four feet in diameter. Under favorable conditions of soil and moisture it is a rapid grower in this locality and soon makes a very beautiful lawn or forest specimen. It is easy to transplant and soon recovers from the shock. Specimens, as in many other conifers, vary greatly as to their beauty. The more silvery specimens being sought for as lawn trees. While it is not entirely hardy alone it does nicely in groups of trees.

JUNIPER communis, Linn. Irish Juniper, Common Juniper. A small pyramidal tree of compact habit and dense silvery gray to dark green foliage. It is extensively used for ornamental hedge purposes since it stands severe pruning remarkably well. While it prefers moist soil it does fairly well on dry soil. The Juniper is rather low for wind-break purposes, but it makes a nice small ornamental tree for parks and lawns. It is easily transplanted but propagated with more or less difficulty from seeds and cuttings.

J. Virginiana, Linn. Red Cedar, Juniper. Native of practically all parts of the United States east of the Rocky Mountains. The Red Cedar varies from a bushy plant in the North to a medium sized tree in the South. It is extensively used for hedges, wind-breaks and lawn trees, being a rapid grower when young but slower when it is older. The Red Cedar grows fairly well in almost any soil but naturally prefers a moist rich soil. It transplants readily but is difficult to propagate since the seed requires two years to germinate.

LARIX Americana, Michx. Tamarack, American Larch. Native of the north and northeastern part of the United States and of the southeastern part of Canada. A tall slender rapid growing forest tree for moist or swampy lands but not valuable for high dry soils. It may be advantageously used in low places for ornamental planting since its beautiful light green foliage is very attractive in early spring and again its light yellow foliage of late autumn contrasts beautifully with the dark green of the pines and spruces. It is easily transplanted if set before growth sets in in the spring.

L. decidna, Mill. European Larch. Native of central part of Europe. A medium sized slender tree often with a more or less drooping habit to its limbs. Like the American Larch it prefers moist, rich soil but will stand drier soils better than the American Larch. It is valuable for forest planting, wind-breaks and ornamental planting. In the eastern states it is used extensively for ornamental and wind-break purposes. As a lawn tree it soon becomes very beautiful and graceful either for specimen or group planting. The European Larch is a much more rapid grower than the American Larch and so for this reason should be substituted for it.

PICEA alba, Link. White Spruce. Native from Labrador to Alaska, and south to Montana and New York. A medium to large pyramidal tree with dense horizontal branches and occasionally pendant branchlets which make it very valuable for ornamental planting. The foliage varies from light green to bluish green or even dark green. Our specimens have made a rapid growth and seem to withstand drouth remarkably well. The White Spruce is also valuable for wind-break purposes and wood lot planting. It is propagated from seed.

P. alba, var., Black Hills Spruce, a natural variety or closely allied species of P. alba, found native in the Black Hills region. It is a medium to a large pyramidal tree with dense stiff foliage and strong upright branches. Its extreme hardiness and ability to withstand our long dry summers make it more valuable for utility planting than the true P. alba, while its compact form and silver specimens make it a valuable plant for ornamental planting. Carefully selected specimens of this species are frequently sold at high prices for the much prized Colorado Blue. The Black Hills Spruce is easily transplanted and readily propagated from seed.

P. Engelmanni, Engelm. Engelman's Spruce. Native of the Rocky Mountains from Arizona to British Columbia. A tall pyramidal tree with slender branches closely arranged so as to form a very compact tree. It has the stiff foliage and frequently the glacous color of the Colorado Blue Spruce and so frequently sold for this species being more common and hence easily obtained. The Engel-

man's Spruce is perfectly hardy, withstands severe drouth and is very ornamental for either specimen or group planting. It is frequently used for hedges since it stands shearing remarkably well and its density makes it valuable for wind-breaks. Propagated from seed.

P. excelsa, Link. Norway Spruce. Native of Europe. A tall growing tree with dense dark green foliage, stiff horizontal branches and usually pendulous branchlets which sweep the ground. It is a rapid grower and when given room makes a very handsome symmetrical tree. Like most spruces it begins to get ragged soon after thirty years of age. Its ease of propagation and rapid growth have caused it to be planted probably more than any other evergreen tree for ornamental purposes, but it is also valuable for shelter belts, hedges and wind-breaks. It is readily propagated from seeds sown early in spring.

P. nigra, Link. Black Spruce. Native of the northern part of the United States and Canada. A small slender, irregular shaped tree, usually with slender pendulous branches. It is not a rapid grower and should be used only on wet, cool soils. The Black Spruce is not desirable for ornamental purposes as it soon loses its lower limbs and becomes unsightly.

P. pungens, Engelm. Colorado Blue Spruce. Native of Wyoming, Colorado and Utah. A dense pyramidal tree from one hundred to one hundred and fifty feet in height with foliage varying from dark green to silvery gray. It is undoubtedly the most ornamental and most highly prized of all evergreens. The silver specimens sell for fancy prices, while trees from the same lot of seed only of a green color sell at moderate prices. After once becoming established it withstands severe drouth and all kinds of neglect with remarkably persistency. As a specimen plant for lawns, parks. etc., the Colorado Blue Spruce has few, if any, equals. The species may be easily propagated from seed, but rare, silver individuals must be grafted or started from cuttings.

P. flexilis, James. Western White Pine. Native of the mountain ranges of the western part of the United States and Canada. A small slender, rather slow growing pine, resembling the White Pine in many ways. It frequently becomes open and round topped in old age and is especially adapted for ornamental planting on rocky situations or where the soil is shallow. It may be propagated by seeds in practically the same manner as other pines.

P. contorto, Dougl. Scrub Pine. Native of the western part of the United States and Canada. A tree that varies from twenty to one hundred feet in height and from a close, compact, pryamidal headed tree to a loose round topped tree. It grows on practically all kinds of soil but usually prefers rich, moist soil. The Scrub Pine is

perfectly hardy and while not a rapid grower it soon forms a good wind-break or an attractive group for ornamental planting. It has many of the characteristics of the Jack Pine and is frequently mistaken for it.

P. divaricata, Dum. Jack Pine. Native of the northern part of the United States and north into Canada to the Arctic Circle. A small to medium sized tree from fifty to one hundred feet high. Of a very irregular, ragged growth, which makes it undesirable for ornamental planting. The young specimens are pretty but they soon become open and unattractive. It is the hardiest native pine on the continent and while it prefers moist, rich soil it will grow fairly well on dry, poor soils. The Jack Pine is very hard to transplant unless small specimens be taken. It can be profitably used in wind-breaks, shelter-belts and wood lots, since the wood may be substituted for Red Pine either for lumber or fuel. The cones have the peculiarity of remaining on the tree for from twelve to fifteen years.

P. laricio. Poir. Austrian Pine. Native of Europe and Asia. A tall, rapid growing pyramidal tree from one hundred to one hundred and fifty feet in height with dense, long dark green leaves and strong spreading branches in regular whorls. It is a valuable tree for wind-breaks, shelter-belts, and wood lot plantations and where a coarse, heavy pine is desired it may be profitably used for ornamental planting. The specimens on the campus are very attractive and have always made satisfactory growths. Small trees are very easily transplanted and while the species favors moist, rich soil, yet it does well upon dry or even rocky soils.

P. Montana mugus, Willk. Dwarf Mountain Pine. Native of Europe. A small dwarf, compact tree seldom growing more than thirty feet high. As a shade or wood producing tree it is comparatively worthless, but it is highly prized for ornamental purposes. It seems to be perfectly hardy and produces a neat and attractive specimen for lawn or park planting.

P. Ponderosa, Dougl. Yellow Pine, Bull Pine. Native of the western part of the United States and Canada. One of the tallest and most important trees of the west. It frequently attains two hundred to three hundred feet in height and is a very valuable lumber tree. Under favorable conditions it is a rapid grower, transplants fairly easy, and is very ornamental from early life to maturity.

P. sylvestris, Linn. Scotch Pine. Native of Europe. A rather large, rapid growing, hardy tree, frequently attaining one hundred and twenty feet in height. When young it is compact and pyramidal in form, but as it grows older it takes on a round, open topped form, and early in life becomes unsightly and begins to die. It has been used extensively on the plains as a wind-break, shade and forest

tree, and while not entirely satisfactory for ornamental purposes it serves its purpose well.

Pseudotsuga Douglasii, Carr. Douglas Spruce, Douglas Fir, Red Fir. Native of the Rocky Mountains and west to the Pacific Ocean. A very large pyramidal tree from two hundred to three hundred feet in height and occasionally twelve feet in diameter at the base of the trunk. This tree is rapidly becoming one of the most popular, if not the most widely planted, trees of the conifer group. It is a rapid grower and soon makes a very graceful, highly ornamental tree. If planted far apart or as specimens and the full effect of its good color and soft foliage is secured by group planting. The Douglas Spruce is very variable in habit from long to short leaves, light to green foliage of from a bluish to a silvery gray colors. It is easily transplanted if small trees from the open woods be taken, but like all conifers, its roots must never become dry. While it would make the best wind-break alone, yet with other trees it would be valuable for this purpose as well as for ornamental and wood lot planting.

Thuya gigantea, Nutt. Giant Cedar. Native of the western coast of North America from Alaska to Northern California. A tall upright growing tree with slightly pendulous branches and a very attractive foliage. This is considered one of the most beautiful native evergreen trees of the United States and while it is not wholly adapted to general planting, yet can be profitably used in moist or protected situations. The Giant Cedar is not difficult to transplant and is usually propagated from seed, but may be multiplied by cuttings taken during the winter.

T. occidentalis, Linn. Arborvitae, White Cedar. Native of the northeastern part of the United States, extending as far west as South Dakota and as far south as North Carolina. A conical shaped tree from fifty to seventy feet in height. If left to grow unpruned it is of a loose, graceful habit, but it can be made to form a dense compact tree by systematic pruning. It grows well on moist soil but is usually poor on dry soil. The Arborvitae is a general favorite for ornamental hedge planting or an occasional specimen on lawns or parks. Where it can be grown as a forest tree it is usually of a rapid growth and the wood is valuable for telegraph poles, fence posts, pails, tubs, etc. It is rather difficult to propagate from seed but can be grown from cuttings.

T. O., var. Ellwangeriana. Tom Thumb Arborvitae.. A dwarf horticultural variety of the common arborvitae with two distinct kinds of foliage making it desirable for ornamental planting. It is a very slow grower, frequently not averaging more than an inch per year. It is readily propagated from cuttings taken during the winter and is easily transplanted.

Fig. 8. Twelve Years' Growth of European Linden

Suggested Trees for Special Planting

I. LARGE, RAPID GROWING TREES FOR STREET AND SHADE

1. Black Locust .... Robinia pseudacacia
2. Carolina Poplar .... Populus deltoides
3. Silver Poplar .... Populus alba
4. Cottonwood .... Populus deltoides
5. Oregon Maple .... Acer macrophyllum*

II. LARGE, MEDIUM GROWING TREES FOR STREET AND SHADE:

1. Norway Maple .... Acer platanoides
2 Sycamore Maple .... Acer pseudo-platanus
3. Silver Maple .... Acer saccharinum
4. Flowering Ash .... Fraxinus ornus
5. Green Ash .... Fraxinus lanceolata
6. Box Elder .... Acer negundo
7. Hackberry .... Celtis occidentalis
8. Black Walnut .... Juglans nigra
9. Scarlet Oak .... Quercus coccinea
10. English Maple .... Acer campestris
11. English Oak .... Quercus sessiliflora
12. Scotch Elm .... Ulmus scabra
13. European Linden .... Tilia vulgaris
14. Horse Chestnut .... Aesculus hippocastanum

III. DECIDUOUS TREES FOR LAWN PLANTING:

1. Cut-leaved Weeping Birch ..Betula alba pendula laciniata
2. English Maple .... Acer campestris
3. Wier's Cut-leaved White Maple..Acer saccharinum Wierii laciniatum
4. European Linden .... Tilia vulgaris
5. American Hornbeam .... Carpinus Caroliniana
6. Japanese Chestnut .... Castanea crenata
7. Flowering Ash .... Fraxinus ornus
8. English Oak .... Quercus sessilflora
9. Scarlet Oak .... Quercus coccinea
10. American Mountain Ash .... Sorbus Americana
11. Bolles Poplar .... Populus alba bolleana
12. Lombardy Poplar .... Populus nigra Italica
13. European Larch .... Larix Europea
14. Golden Willow .... Salix vittellina
15. White Birch .... Betula alba
16. Red Maple .... Acer rubrum
17. Native Thorn .... Crataegus Douglassi

IV. EVERGREEN TREES FOR LAWN PLANTING:

1. Colorado Blue Spruce .... Picea pungens
2. Douglas Fir .... Pseudo-tsuga Douglassi
3. Engleman's Spruce .... Picea Englemanni
4. Black Hills Spruce .... Picea alba, var.
5. Norway Spruce .... Picea excelsa
6. Scotch Pine .... Pinus sylvestris
7. Dwarf Mountain Pine .... Pinus Montana Mugus
8. Austrian Pine .... Pinus laricio
9. Irish Juniper .... Juniper communis
10. Giant Cedar .... Thuya gigantea

V. THE BEST TREES FOR SINGLE ROW WIND-BREAKS OR TALL SCREENS:

1. White Willow .... Salix alba
2. Lombardy Poplar .... Populus nigra, Italica

3. Oregon Maple .... Acer macrophyllum*
4. Box Elder .... Acer negundo
5. Douglas Fir .... Pseudo-tsuga Douglassi
6. Scotch Pine .... Pinus sysvestris
7. Austrian Pine .... Pinus laricio

VI. THE BEST TREES FOR SINGLE ROW WIND-BREAK OR LOW SCREEN:

1. English Maple .... Acer campestris
2. Golden Willow .... Salix vittelina
3 American Hornbeam .... Carpinus Caroliniana
4. Native Thorn .... Crataegus Douglassi
5. Russian Wild Olive .... Elaeagnus angustifolia
6. Engleman's Spruce .... Picea Englemanni
7. White Spruce .... Picea alba

VII. THE BEST TREES TO PLANT FOR FUEL PURPOSES:

1. White Willow .... Salix blanda
2. European Larch .... Larix Europea
3. Black Locust .... Robinia pseudocacia
4.Cottonwood .... Populus deltoides
5. Austrian Pine .... Pinus lausico
6. White Maple .... Acer saccharinum

*For west of the Cascade Mountains.

THE STATE COLLEGE OF WASHINGTON

Agricultural Experiment Station
Pullman, Washington

DEPARTMENT OF CHEMISTRY

Wheat and Flour Investigations

(CROPS OF 1906-7)

By R. W. THATCHER

Bulletin No. 91
1910

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Wheat and Flour Investigations

(CROPS OF 1906-7)

BY R. W. THATCHER

The Chemistry Department of this Station has in progress a series of investigations of the chemical composition and milling qualities of Washington wheats. These investigations have a two-fold purpose. One important object is to ascertain the comparative value for flour production of the different varieties of wheat which are now being grown in different parts of the State. This is a matter of both scientific and practical interest and value, and if once definitely established may serve several important purposes. The other object of the investigations is to discover, if possible, the causes of variations in composition of wheat and to utilize the knowledge thus gained in improving the quality of the grain either by proper breeding or by proper control of the influences which tend to cause deterioration in quality.

It is obvious that a thorough knowledge of the composition of the grain as it is now grown is the first and fundamental step in these investigations. For this purpose, it was planned to collect and submit to complete analytical and milling tests typical samples of all the varieties commonly grown, from each of the wheat-growing districts of the State, for five successive years, or seasons. It is believed that the results of the tests made on these five successive crops, grown under the varying conditions of the different seasons in each of the different localities, when summarized and averaged, will give a correct knowledge of the average composition of each of the varieties studied, and of the variations which may reasonably be expected to result from varying conditions under which the same variety is grown.

The general methods of securing the samples and of testing

them in the Station laboratories, together with the results of the first year's tests, on samples of the crop of 1905, have been published as Bulletin No. 84. The collection of samples of the crops of 1906 and 1907 has now been completed and the results are recorded in this bulletin. It is proposed to present the results of the same investigations on the crops of 1908 and 1909, together with a sumary of the five years' work and final conclusions which may be drawn from it in a later bulletin to be published as soon as the investigations can be completed.

For complete details of the methods employed in these investigations, and for a general discussion of the principles involved and their application to these studies, interested readers are referred to Bulletin No. 84. In the following pages, only such brief explanations as will make the tables intelligible, together with short descriptions of any new additions to or modifications of the methods of study, are presented.

THE CROP OF 1906

In the fall of 1906, those millers, warehousemen, grain dealers, and farmers who had furnished samples for the studies of the crop of 1905, were requested to submit similar samples of the crop of 1906, and in most cases willingly consented to do so. Some additional co-operation was also secured from localities not formerly represented. Sacks, blank forms for supplying information concerning the samples, shipping tags, and directions for preparing and shipping the samples were sent out from the Station laboratory. A total of ninety-two samples were received, representing twenty-one different shipping points and sixteen different varieties. There was an easily noticeable disposition on the part of the persons who sent in the samples to select those varieties which are commonly considered to be of higher market grade as the typical wheats of their locality, so that the total number of samples of these varieties is greater than that of some of the other varieties of lower market grade, which may be nearly as commonly grown.

The harvest of 1906 was marked by very hot dry weather and much of the grain of the wheat-producing portions of the State did not mature normally and was more or less shrunken.

With the belief that these conditions afforded an excellent opportunity of studying the effect of rapid maturity, or shortened ripening period, upon the quality of the grain, and the relative value of plump and shrivelled grain for milling purposes several of the persons who expressed their willingness to secure samples for the work were requested to get samples of plump, slightly shrunken, and badly shrivelled grain of the same variety and grown in the same locality, if possible.

The information accompanying each sample, together with notes as to its condition and its weight per bushel, as determined either by the shipper or by a laboratory assistant, are given in Table I.

TABLE I. DESCRIPTION OF SAMPLES—CROP OF 1906

No.	Variety	Grown by	Grown at	County	Bu. pr Acre	Cond'n	Test wt per Bu.
1703	Fife		Hatton	Adams		p	61
1704	Fife		Hatton	Adams		ss	58½
1705	Fife		Hatton	Adams		bs	52
1706	Bluestem		Hatton	Adams		p	57½
1707	Bluestem		Hatton	Adams		bs	45
1708	Fortyfold		Hatton	Adams		ss	56½
1709	Turkey Red		Hatton	Adams		p	59½
1773	Bluestem	Robt. Hankell	Hartline	Lincoln	21	p	heavy
1774	Bluestem	Robt. Hankell	Hartline	Lincoln	21	s	light
1775	Red Allen	D. O. Hughes	Hartline	Lincoln	20	p	61½
1776	Red Allen	D. O. Hughes	Hartline	Lincoln	20	s	light
1777	Sonora	D. O. Hughes	Hartline	Lincoln	22	p	62½
1778	Fife	Reinhart Bros.,	Hartline	Lincoln	21	p	58
1779	Turkey Red	G. J. Weeks	Hartline	Lincoln	32	p	61
1780	Bluestem	C. H. Spurbeck	Genesee	Latah, Idaho	31	p	61
1781	Little Club	Keane & Martinson	Genesee	Latah, Idaho	25	p	60
1782	Fortyfold	Keane & Martinson	Genesee	Latah, Idaho	30	p	58
1783	Red Russian	A. L. Stewart	Genesee	Latah, Idaho	38	p	56
1784	Turkey Red	W. H. Gage	Genesee	Latah, Idaho	35	p	60½
1785	Macaroni	S. D. White	Genesee	Latah, Idaho	25	p	61
1786	Squarehead	Miller Bros.,	Genesee	Latah, Idaho		p	58
1790	Bluestem	G. P. Howard	St. John	Whitman		p	61
1791	Bluestem	G. P. Howard	St. John	Whitman	20	bs	52
1792	Fife	G. P. Howard	St. John	Whitman	34	p	59½
1793	Red Chaff	G. P. Howard	St. John	Whitman	20	ss	58
1794	Turkey Red	G. P. Howard	St. John	Whitman	31	p	61
1795	Fortyfold	Joe Bach	St. John	Whitman	39	p	57½
1796	White Amber	C. P. Howard	St. John	Whitman		p	59½
1815	Bluestem	F. D. Rinehart	Alto	Columbia	38½	p	59½
1816	Bluestem	H. H. Vincent	Prescott	Walla Walla	20	bs	54
1817	Little Club	D. C. Eaton	Waitsburg	Columbia	44	p	58

TABLE I. DESCRIPTION OF SAMPLES—CROP OF 1906—CONTINUED

No.	Variety	Grown by	Grown at	County	Bu. pr Acre	Cond'n	Test wt per Bu.
1870	White Amber	....	Tekoa	Whitman	....	p	57½
1871	Genesee Giant	....	Tekoa	Whitman	....	p	61
1891	Bluestem	....	Ritzville	Adams	....	s	54½
1892	Fife	....	Ritzville	Adams	....	p	57½
1893	Turkey Red	....	Ritzville	Adams	....	p	60½
1894	Sonora	D. A. Scott	Ritzville	Adams	....	p	57
1901	Bluestem	Geo. Strahan	Winona	Whitman	....	p	56½
1902	Fife	Gottlieb Price	Winona	Whitman	....	ss	56
1903	Turkey Red	Geo. Duncan	Winona	Whitman	....	p	60
1904	Fortyfold	Bert Lemon	Winona	Whitman	....	p	56½
1905	Bluestem	....	Willada	Whitman	....	p	56
1906	Little Club	J. P. Hegerman	Willada	Whitman	....	p	57
1907	Chili Club	Nelson Bros.,	Willada	Whitman	....	p	56½
1908	Fife	H. Tonks	Willada	Whitman	....	p	57
1909	Sonora	H. Bethke	Willada	Whitman	....	p	61
1968	Bluestem	J. L. Horrell	Kiona	Benton	....	ss	54
1969	Bluestem	....	Kiona	Benton	....	bs	51
1970	Fife	W. C. Travis	Kiona	Benton	....	p	56½
1971	Turkey Red	E. H. McBee	Kiona	Benton	....	p	60
1972	Turkey Red	....	Theon	Asotin	38	p	60½
1973	Turkey Red	....	Anatone	Asotin	35	ss	58
1974	Red Russian	....	Anatone	Asotin	29	bs	54
1975	Fortyfold	....	Anatone	Asotin	40	p	59
1976	Bluestem	J. H. Green	Tonk Creek	Okanogan	20	p	58½
1977	Bluestem	French Bros.,	Tonk Creek	Okanogan	....	p	59½
1978	Bluestem	J. H. Green	Tonk Creek	Okanogan	....	p	58½
1979	Fife	....	Riverside	Okanogan	18	p	59
1980	Fife	S. Sogle	Riverside	Okanogan	45	p	60½
1981	Macaroni	J. H. Green	Tonk Creek	Okanogan	....	p	61½
1982	Sonora	S. Sogle	Riverside	Okanogan	26	ss	58
1999	Fortyfold	H. A. Smith	Kiona	Benton	25	p	...

TABLE 1. DESCRIPTION OF SAMPLES—CROP OF 1906—CONTINUED

No,	Variety	Growh by	Grown at	County	Bu. pr Acre	Cond'n	Test wt per Bu
1818	Little Club	W. H. Hill	Waitsburg	Columbia	....	s	57
1819	Red Chaff	Arnold Bros.,	Waitsburg	Columbia	40	p	58
1820	Dale	N. B. Atkinson	Waitsburg	Columbia	45	p	60½
1821	Bluestem	J. Groom	Colfax	Whitman	....	p	57
1822	Red Chaff	Mason & Lynch	Colfax	Whitman	....	ss	56½
1823	Fife	P. R. Lair	Colfax	Whitman	....	p	59
1824	White Amber	A. E. Kirkland	Colfax	Whitman	....	p	58
1825	Turkey Red	Dr. Ferguson	Colfax	Whitman	30	p	60½
1826	Red Russian	R. L. Huffman	Colfax	Whitman	....	p	56
1827	Macaroni	N. Nelson	Colfax	Whitman	....	p	61½
1828	Bluestem	H. C. Calvin	Albion	Whitman	....	p	56
1829	Little Club	Wm. Thompson	Albion	Whitman	....	p	57
1830	Red Russian	Burrell Inv. Co.,	Albion	Whitman	....	p	57
1831	Red Russian	Henry Fowler	Diamond	Whitman	27	p	58
1832	Red Chaff	Henry Hickman	Almota	Whitman	32	p	60½
1833	Bluestem	S. C. Armstrong	Winona	Whitman	....	ss	55
1837	Bluestem	Moore Bros.,	Kahlotus	Whitman	30	p	56½
1838	Fife	W. A. Langdon	Kahlotus	Whitman	25	p	57
1839	Fife	Sorrels Bros.,	Kahlotus	Whitman	25	ss	56
1840	Turkey Red	Wm. Goodenough	Kahlotus	Whitman	....	bs	56
1841	Fortyfold	A. J. Williams	Kahlotus	Whitman	25	p	57½
1860	Fife	J. S. Withrow	Waterville	Douglas	22	p	60
1861	Red Allen	Jos. Muldoon	Waterville	Douglas	20	p	60
1862	Red Allen	A. Inner	Waterville	Douglas	....	p	60
1863	White Elliott	E. L. Ballard	Waterville	Douglas	27	p	61
1864	White Elliott	C. M. Hensel	Waterville	Douglas	30	p	59½
1865	White Amber	J. E. Andrews	Waterville	Douglas	20	p	59
1866	Bluestem	...	Tekoa	Whitman	....	p	58½
1867	Bluestem	...	Tekoa	Whitman	....	s	56
1868	N. D. Bluestem	...	Tekoa	Whitman	....	ss	56½
1869	Little Club	...	Tekoa	Whitman	....	p	60

The samples are arranged in the table in the order in which they were received at the laboratory, and each is designated by the laboratory number which was assigned to it, by means of which it may be identified in later tables in this bulletin. The second, third, fourth and fifth columns show the variety, grower's name, nearest shipping point and county where the grain was grown, for each sample concerning which this data was supplied by the shipper. The sixth column contains the exact or approximate yield per acre of the crop from which the sample was taken. The seventh column indicates the condition of the grain as observed at the laboratory "P" signifying plump; "SS," slightly shrunken; "S," shrunken; and "BS," badly shrivelled. The final column shows the test weight per bushel as determined by the ordinary Fairbanks grain grader.

In addition to these samples of wheat from this State similar samples were also secured from the Agricultural Department of the Experiment Stations in several of the great wheat-growing States of the Mississippi Valley. In each case, these samples were received in response to a request for representative average samples of the varieties of wheat most commonly grown in that particular State. These were secured for the purpose of submitting them to the same tests under identically the same conditions as our Washington wheats were being tested, in order that the composition and milling quality of our grains might be compared with those grown in the Mississippi Valley States. The total number of these eastern grown wheats which were received and tested was twenty, distributed as follows: Kansas, five; Illinois, four; North Dakota, and South Dakota; three each; Nebraska and Minnesota, two each and Tennessee, one. An additional sample from a miller in central Nebraska, and one from central Ohio were also received and submitted to similar tests. In the main, the varieties represented by these Eastern States are different than those collected in Washington, so that the comparisons to be drawn from the results of the tests cannot be said to show the effects of the different conditions existing in these several States upon the same variety of wheat. They do, however, afford a basis of comparison of the quality and compo-

sition of the prevailing wheats of the States represented with those of the same season's crop grown in Washington. It should, perhaps, be mentioned in this connection that the Bluestem wheat received from Minnesota and North Dakota is a different variety from that known by the same name in this State, the former being a red, small-berried variety originating in Europe, while the bluestem of the Pacific Coast States is a white large-berried grain originally imported from Australia. It is intended to secure similar samples of Eastern wheats of other season's growth, for similar comparisons with Washington wheats of the same season, in order to avoid the possibilities of drawing erroneous conclusions from the results of a single year's samples.

Results of the Tests

The results of the analyses of the wheat, the percentages of each of the three mill-products (flour, bran and shorts) obtained in the experimental milling of samples, the gluten tests of the flour in each case, and the percentage of crude protein found in the bran, shorts and flour from each sample, are shown in Table II.

TABLE II. RESULTS OF TESTS ON WASHINGTON WHEATS—CROP OF 1906

Variety	Smpl No.	Quality	Analysis of the Wheat				Y'ld of Mill Pdcts			Gluten in Flour		Protein in Mill Pr'dcts			Sample No.
			Moistre	Ash	Crude Prot'n	Carbo and Oil	Bran	Shrts	Flour	Wet	Dry	Bran	Shorts	Flour	
Bluestem........	1706	Medium ...	11.09	1.91	12.69	74.31									1706
	1707	Shrivelled.	9.16	2.50	18.43	69.91									1707
	1773	Heavy	13.20	2.10	14.20	70.50	17.8	12.1	70.1	35.23	12.72	17.85	17.68	12.14	1773
	1774	Light	13.28	2.19	16.08	68.45	16.9	13.3	68.8	46.92	16.37	20.17	19.99	15.00	1774
	1780	Heavy	12.43	1.83	10.31	75.43	15.5	11.1	73.4	24.27	9.10	13.15	14.72	9.47	1780
	1790	Heavy	13.90	2.01	13.07	71.02	15.6	11.7	72.5	31.60	11.44	15.97	16.80	11.57	1790
	1791	Light	12.37	2.29	15.41	68.93	16.9	12.9	70.2	43.85	16.13	18.81	19.53	14.03	1791
	1815	Heavy	12.37	2.07	11.73	74.83	15.3	12.1	72.6	29.35	10.85	15.39	15.34	10.43	1815
	1816	Light	11.72	2.23	13.88	72.17	17.2	12.9	69.8	35.56	13.27	17.55	....	13.19	1816
	1828	Medium ..	11.90	1.72	11.60	74.78	15.7	14.7	69.6	29.47	11.04	13.93	14.95	10.34	1828
	1833	Light	9.37	2.34	15.65	72.64									1833
	1837	Medium ...	10.21	2.12	11.45	76.22	17.0	12.6	70.4	29.06	10.36	13.47	14.95	10.20	1837
	1866	Heavy	12.47	1.82	14.55	71.16	15.0	15.6	69.4	37.67	13.90	19.30	18.94	12.75	1866
	1867	Medium ...	11.22	2.12	15.94	70.72	16.5	14.6	68.9	43.17	15.81	17.82	18.69	14.03	1867
	1868	Medium ...	13.71	2.08	13.36	70.85	15.8	12.2	72.0	35.45	13.07	15.15	14.79	12.66	1868
	1882	Heavy	11.24	2.40	10.31	76.05									1882
	1891	Medium ...	9.76	2.61	14.34	73.29	15.7	13.7	70.6	37.10	14.74	17.59	18.25	13.02	1891
	1901	Medium ...	10.30	2.11	13.10	74.49	16.2	12.2	71.8	32.55	11.97	16.39	16.80	11.63	1901
	1905	Medium ...	10.30	2.31	12.87	74.52	15.6	12.5	71.9	32.20	11.78	14.16	16.53	11.60	1905
	1968	Light	9.62	2.55	15.42	72.41	17.0	14.4	68.6	41.34	15.19	17.22	18.12	13.97	1968
	1969	Shrivelled.	10.40	2.83	17.52	70.25	16.4	13.7	69.9	46.90	17.23	20.34	19.74	15.97	1969
	1976	Heavy	10.30	1.93	11.85	75.90	17.5	14.0	68.5	28.35	10.26	14.70	15.81	10.23	1976
	1977	Heavy	10.08	2.15	12.26	75.51	17.0	12.5	70.5	31.28	11.27	15.55	15.64	10.85	1977
	1978	Heavy	9.76	2.18	13.88	74.18	15.5	13.5	71.0	39.65	15.17	17.73	17.10	12.84	1978
	Maximum		13.90	2.83	18.43	76.22	17.8	15.6	73.4	46.92	17.23	20.34	19.99	15.97	
	Minimum		9.16	1.72	10.31	68.45	15.0	11.1	68.5	24.27	9.10	13.15	14.72	9.47	
	Average		11.25	2.18	13.75	72.82	16.3	13.4	70.3	35.50	13.08	16.61	16.72	12.30	
Jones' Fife......	1703	Heavy	9.38	1.62	9.99	79.01									1703
	1704	Medium ...	8.93	1.86	12.25	76.96									1704
	1705	Shrivelled .	9.24	1.89	14.62	74.25									1705

TABLE II. RESULTS OF TESTS ON WASHINGTON WHEATS—CROP OF 1906—CONTINUED.

Variety	Smpl No.	Quality	Analysis of the Wheat				Y'ld of Mill Pcdts			Gluten in Flour		Protein in Mill Pr'dcts			Sample No.
			Moistre	Ash	Crude Prot'n	Carbo. and Oil	Bran	Shrts	Flour	Wet	Dry	Bran	Shorts	Flour	
Jones' Fife......	1778	Medium ...	13.44	1.91	14.05	70.60	15.1	13.7	71.2	37.42	14.13	17.64	18.25	13.02	1778
(Continued)	1792	Heavy	12.35	1.39	10.82	75.44	16.0	12.6	71.4	22.67	8.52	13.09	13.77	9.80	1792
	1823	Heavy	11.01	1.70	10.76	76.53	15.1	13.5	71.4	20.06	7.62	12.69	13.81	10.40	1823
	1838	Heavy	9.52	1.81	12.29	76.38	15.1	12.7	72.2	29.00	10.65	14.53	14.20	11.37	1838
	1839	Medium ...	9.45	2.01	15.06	73.48	15.0	12.3	72.7	34.20	12.68	18.21	18.48	14.05	1839
	1860	Heavy	11.96	1.71	9.60	76.73	14.2	12.2	73.6	19.37	7.28				1860
	1892	Medium ...	10.15	1.94	13.39	74.52	16.0	12.2	71.8	31.68	12.06	15.85	15.25	12.29	1892
	1902	Medium ...	9.93	2.19	13.59	74.29	17.0	12.5	70.5	29.75	11.18	16.27	16.27	12.87	1902
	1908	Medium ...	10.04	1.85	12.87	75.24	15.3	12.4	72.3	28.83	11.01	15.93	15.42	12.17	1908
	19[illegible]	Light	9.21	2.45	13.50	74.84	16.5	13.2	70.3	35.61	13.56	15.25	14.67	12.20	1970
	1979	Heavy	8.66	2.10	11.09	78.15	15.1	12.7	72.2	26.05	9.54	13.68	14.25	10.11	1979
	1980	Heavy	8.70	1.89	11.16	78.25	15.5	12.0	72.5	18.27	7.02	13.42	13.38	10.23	1980
	Maximum		13.44	2.45	15.06	79.01	17.0	13.7	73.6	37.42	14.13	18.24	18.48	14.05	
	Minimum		8.66	1.62	9.60	70.60	14.2	12.2	70.3	18.27	7.02	12.69	13.38	9.80	
	Average		10.13	1.87	12.34	75.66	15.5	12.7	71.8	27.74	10.44	15.14	15.22	11.68	
Little Club.....	1781	Heavy	11.80	1.78	10.23	76.19	15.4	12.6	72.0	27.00	10.91	12.30	13.26	9.32	1781
	1817	Medium ...	11.10	1.79	9.69	77.42	15.5	11.5	73.0	23.48	9.50	10.69	11.58	8.95	1817
	1818	Medium ...	11.37	2.16	13.88	72.59	16.6	11.4	72.0	39.10	14.74	16.18	16.30	12.63	1818
	1829	Medium ...	11.29	2.10	15.50	71.11	15.5	13.0	71.5	38.99	15.22	15.76	15.97	15.15	1829
	1869	Heavy	12.27	2.00	9.69	76.04	16.3	12.5	71.2	22.55	8.23	12.46	13.26	8.65	1869
	1906	Medium ...	10.07	2.05	10.34	77.54	16.0	13.0	71.0	25.80	9.72	12.55	14.49	9.38	1906
Chili Club......	1907	Medium ...	10.87	1.80	11.23	76.10	16.0	13.5	70.5	27.15	10.62	14.11	14.20	10.17	1907
Red Chaff......	1793	Medium ...	12.98	1.28	11.16	74.58	16.6	15.2	68.2	25.36	9.50	14.16	14.40	10.14	1793
	1819	Medium ...	11.09	1.81	8.37	78.73	16.2	11.5	72.3	16.74	6.94	9.79	11.44	7.77	1819
	1822	Light	10.65	1.92	10.45	76.98	17.0	13.2	69.8	25.84	9.61	13.15	13.77	9.38	1822
	1832	Heavy	9.18	2.09	9.80	78.93	16.0	13.2	70.8	20.17	7.56	10.99	12.72	8.98	1832
	Maximum		12.98	2.16	13.88	78.93	17.0	15.2	73.0	38.99	15.22	16.18	16.30	15.15	
	Minimum		9.18	1.28	8.37	71.11	15.4	11.4	68.2	16.74	6.94	9.79	11.44	7.77	
	Average		11.15	1.80	10.94	76.01	16.1	12.8	71.1	26.56	10.26	12.94	13.76	9.87	

TABLE II. RESULTS OF TESTS ON WASHINGTON WHEATS—CROP OF 1906—CONTINUED

Variety	Smpl No.	Quality	Analysis of the wheat				Y'ld of Mill Prdcts			Gluten in Flour		Protein in Mill Pr'dcts			Sample No.
			Moistre	Ash	Crude Prot'n	Carbo. and Oil	Bran	Shrts	Flour	Dry	Wet	Bran	Shorts	Flour	
Turkey Red ...	1709	Heavy	9.07	1.62	11.14	78.17	14.4	12.2	73.4	26.22	9.33	13.70	13.35	10.31	1709
	1779	Heavy	12.36	1.68	13.36	72.60	15.5	14.4	70.1	39.00	12.78	15.46	15.25	12.75	1779
	1784	Heavy	12.77	1.62	12.37	73.24	16.0	12.0	72.0	37.74	12.48	12.05	14.70	11.73	1784
	1794	Heavy	12.64	1.69	11.90	73.77	16.2	14.9	68.9	32.97	12.26	14.37	14.74	11.27	1794
	1825	Heavy	11.21	1.84	10.96	75.99	15.9	14.0	70.1	29.83	10.95	12.64	12.73	10.60	1825
	1840	Light	9.78	1.85	14.74	73.63	15.2	13.7	71.1	38.28	13.45	15.91	15.97	13.39	1840
	1893	Heavy	9.34	1.76	11.99	76.91	15.5	14.2	70.3	31.77	11.56	14.07	13.89	11.64	1893
	1903	Heavy	10.56	2.12	14.03	73.29	15.1	12.3	72.6	40.15	14.64	16.18	15.55	14.05	1903
	1971	Heavy	8.96	1.96	12.48	76.60	15.0	15.7	69.3	36.00	12.88	13.98	13.86	12.14	1971
	1972	Medium ...	10.59	1.75	10.70	76.96	13.8	14.4	71.8	28.06	10.22	11.70	13.54	10.11	1972
	1973	Heavy	9.28	1.40	15.33	73.99	15.6	14.8	69.6	45.26	15.16	18.21	16.05	14.68	1973
	Maximum		12.77	2.12	15.33	78.17	16.2	15.7	73.4	45.26	15.16	18.21	16.05	14.68	
	Minimum		8.96	1.40	10.70	72.60	13.8	12.0	68.9	26.22	9.33	11.70	12.73	10.11	
	Average		10.60	1.75	12.64	75.01	15.3	14.1	70.6	35.03	12.35	14.39	14.42	12.06	
Forty Fold	1708	Light	10.97	1.50	13.09	74.44	14.9	12.9	72.2	26.72	9.46	15.34	16.35	11.57	1708
	1782	Medium ...	13.10	1.67	10.54	74.69	14.5	13.2	72.3	20.70	7.84	12.34	13.20	9.69	1782
	1795	Medium ...	12.62	1.62	10.85	74.91	16.7	11.5	71.8	24.65	9.53	12.85	14.63	9.78	1795
	1841	Medium ...	9.86	2.17	14.05	73.88	15.3	13.7	71.0	26.12	9.77	17.05	16.95	12.72	1841
	1904	Light	10.46	1.92	12.84	74.78	15.5	10.7	73.8	28.01	11.40	16.59	16.95	11.82	1904
	1975	Heavy	9.82	1.76	10.03	78.19	15.9	12.7	71.4	19.52	7.52	12.34	13.77	9.61	1975
	Maximum		13.10	2.17	13.09	78.19	16.7	12.9	73.8	28.01	11.40	17.05	16.95	12.72	
	Minimum		9.82	1.50	10.03	73.88	14.5	10.7	71.0	19.52	7.52	12.34	13.20	9.61	
	Average		11.14	1.77	11.90	75.19	15.5	12.4	72.1	24.29	9.25	14.42	15.31	10.86	
Red Russian ..	1783	Medium ...	12.65	1.60	9.26	76.49	16.7	13.7	69.6	20.84	7.73	11.62	13.05	8.26	1783
	1826	Medium ...	11.24	1.85	10.65	76.26	16.6	13.0	70.4	26.85	9.87	13.47	14.95	9.41	1826
	1830	Heavy	11.04	1.78	10.09	77.09	16.9	12.7	70.4	22.95	8.59	13.05	14.11	8.98	1830
	1831	Heavy	9.43	1.99	10.20	78.38	16.4	12.0	71.6	23.82	9.22	12.78	13.81	9.38	1831
	1974	Light	9.84	1.95	12.93	75.28	16.8	12.7	70.5	37.07	14.37	15.30	15.09	11.85	1974
	Maximum		12.65	1.99	12.93	78.38	16.9	13.7	71.6	37.07	14.37	15.30	15.09	11.85	
	Minimum		9.43	1.60	9.26	75.28	16.4	12.0	69.6	20.84	7.73	11.62	13.05	8.26	
	Average		10.84	1.83	10.62	76.71	16.7	12.8	70.5	26.31	9.96	13.24	14.20	9.58	

TABLE II. RESULTS OF TESTS ON WASHINGTON WHEATS—CROP OF 1906—CONTINUED

Variety	Smpl No.	Quality	Analysis of the Wheat				Y'ld of Mill Pdcts			Gluten in Flour		Protein in Mill Pr'dcts			Sample No.
			Moistre	Ash	Crude Prot'n	Carbo. and Oil	Bran	Shrts	Flour	Wet	Dry	Bran	Shorts	Flour	
Macaroni........	1407	Light	9.70	2.14	14.53	73.63									1407
	1785	Heavy	12.62	2.27	12.93	71.18	16.0	15.5	68.5	38.20	14.18	14.67	14.44	12.63	1785
	1827	Heavy	9.62	1.83	12.17	76.38	15.1	13.2	71.7	30.67	11.78	13.26	13.35	11.67	1827
	1981	Heavy	9.82	2.14	11.90	76.14	15.7	10.4	73.9	32.35	12.34	12.97	12.97	11.70	1981
Sonora	1777	Heavy	13.55	1.75	12.55	72.15	14.3	13.4	72.3	29.99	11.07	15.30	16.05	11.40	1777
	1894	Medium ...	9.27	1.98	15.71	72.88	13.4	12.0	74.6	40.98	14.70	18.43	17.77	14.46	1894
	1909	Heavy	9.16	1.58	11.57	77.69	15.9	11.9	72.2	27.55	10.97	13.63	13.54	10.31	1909
	1982	Medium ...	9.07	1.82	10.14	78.97	16.1	14.3	69.6	22.17	8.67	12.34	12.34	9.50	1982
White Amber..	1796	Heavy	13.31	1.57	10.87	74.25	16.5	12.5	71.0	29.25	11.17	13.72	15.98	9.83	1796
	1824	Medium ...	11.04	2.07	11.27	75.62	16.0	13.6	70.4	28.23	11.19	13.77	12.51	10.40	1824
	1865	Heavy	11.27	1.74	11.82	75.17	16.5	14.0	69.5	32.06	12.21	13.98	13.98	10.93	1865
	1870	Medium ...	13.14	1.70	9.94	75.22				23.34	8.91	12.30	13.72	8.80	1870
Red Allen......	1775	Heavy	12.41	1.87	12.32	73.40	15.0	12.8	72.2	32.91	11.64	15.65	15.93	11.09	1775
	1776	Medium ...	12.47	1.98	12.84	72.71	16.8	12.6	70.6	34.60	12.21	16.35	17.77	11.48	1776
	1861	Heavy	12.10	1.80	10.85	75.25	15.7	11.7	72.6	28.16	10.15	14.16	14.67	9.66	1861
	1862	Heavy	12.12	1.92	11.16	74.80	15.7	12.0	72.3	28.72	10.70	14.49	14.95	9.86	1862
White Elliot....	1863	Heavy	10.50	2.06	13.16	74.28	15.7	12.0	72.3	35.08	13.32	17.31	14.91	11.99	1863
	1864	Heavy	10.44	1.76	12.34	75.46	17.8	13.1	69.1	30.15	10.81	16.27	15.55	10.60	1864
Genesee Giant	1871	Heavy	12.98	2.05	11.30	73.67	16.2	11.5	72.3	29.39	11.33	14.02	14.34	10.37	1871
Squarehead....	1786	Medium ...	12.50	2.01	10.43	75.06	15.9	13.1	71.0	26.04	10.20	13.23	14.20	9.58	1786
Dale	1820	Heavy	10.81	1.85	10.11	77.23	16.3	12.2	71.5	22.52	9.00	12.18	12.30	9.54	1820

In this table, each sample is designated by its laboratory number, and all the samples of the same variety are grouped together, being arranged in the numerical order of their laboratory numbers without regard to their origin or quality as shown in Table I. However, there has been inserted in the third column of the table a note concerning the quality of the grain in the samples using the conventional terms of "heavy," "light," etc. which are commonly employed for this purpose in order that improper conclusions may not be drawn from some of the analytical figures. In the case of those varieties of which a considerable number of samples were tested, the maximum, minimum, and average percentage of each constituent which was determined, has been inserted, in order to facilitate comparisons between varieties.

The method of operation of the tests applied to each sample have been described in detail in Bulletin No. 84 and need not be repeated here.

The results recorded in the table afford a basis of comparison of the average quality of the different varieties represented by these samples, for the season of 1906. In general these relationships are the same as shown by the crop of 1905. The percentage of protein in the wheat and flour and the gluten tests on the flour are higher in every case than in the samples of 1905, showing the effect of the hot weather during harvest in increasing the percentage of nitrogenous matter by cutting short the deposition of starch in the ripening grain. The relative rank of the several varieties in protein content is the same as in the preceding year.

The relation in composition of light weight or shrivelled grain to heavier or plumper wheat grown in the same locality is shown in the table to be that in every case the lighter grain is richer in per cent of protein and yields flour of higher gluten test. The total yield of flour is usually greater in the heavier wheat, the percentage of bran being nearly always higher in the lighter grain. The differences in yield of total or "straight" flour were not so great as was anticipated, however. The facilities for experimental milling do not permit the separation of the flour into "patent" and "baker's" grades, hence it was

impossible to determine the effect of the shrivelling of the grain upon the percentage yield of "patent" flour. It would appear, from the results of these tests, that the slightly decreased yield of flour from the light weight grain is at least fully compensated for by the increased food and baking value due to the increased protein, or gluten content of the flour, and that the practice of discriminating in market prices against the lighter weight grain is not justifiable from the standpoint of total flour production. This would be especially true in those localities and under those conditions where the mill by-products have a commercial value not much lower than the selling value of flour. Under these circumstances, the slight decrease in the yield of flour and increase in the percentage of bran makes a very small difference in the total value of the product. If, then, the increased food and baking value of the flour from the lighter grain is taken into consideration it would appear that the light weight grain is fully as valuable for milling purposes as heavier wheat. It will take more extensive milling tests to determine whether the yield of "patent" flour is seriously lowered by the failure of the grain to thoroughly mature in seasons of short ripening periods.

The results of the same tests upon the Eastern-grown wheats are shown in Table III.

TABLE III. RESULTS OF TESTS ON EASTERN WHEATS.

Variety	Smpl No.	Where Grown	Analysis of the Wheat: Moistre	Ash	Crude Prot'n	Carbo and Oil	Y'ld of Mill Pdcts: Bran	Shrts	Flour	Gluten in Flour: Wet	Dry	Protein in Mill. Pr'dcts: Bran	Shorts	Flour	Sample No.
Turkey Red...	1423	Kansas	10.57	1.42	16.29	71.72	14.4	12.0	73.6	41.86	14.45	19.44	18.81	15.18	1423
	1487	Nebraska ..	10.34	2.25	14.11	73.30	14.9	11.9	73.2	34.73	11.77	16.48	17.64	12.54	1487
	1489	Illinois	13.72	1.29	9.75	75.24	13.1	12.4	73.5	22.27	8.43	12.46	14.31	8.92	1489
	1919	Ohio	9.13	1.90	12.51	76.46									1919
	1938	Nebraska ..	11.91	1.83	11.34	74.92									1938
Fife.........	1414	No. Dakota .	11.00	2.67	12.87	73.46	16.9	13.6	69.5	31.39	11.55	13.86	16.23	12.11	1414
	1421	Kansas	11.03	1.47	13.16	74.34	14.9	12.3	72.8	30.49	10.87	16.18	16.90	11.96	1421
	1507	Minnesota ..	14.42	2.50	13.47	69.61	15.2	12.5	72.3	32.81	12.52	15.85	16.39	12.52	1507
Bluestem,........	1413	No. Dakota .	10.96	2.44	13.62	72.98	16.1	12.8	71.1	34.36	12.49	15.13	15.93	12.51	1413
	1506	Minnesota .	13.50	2.16	12.84	71.50	15.2	13.1	71.7	32.24	11.58	13.68	15.60	12.17	1506
Fulcaster..	1425	Kansas	11.27	1.98	16.55	70.20	15.0	13.1	71.9	42.45	15.02	21.78	20.34	14.40	1425
	1724	Tennessee ..	11.91	1.93	15.21	70.95	17.2	12.9	70.1	36.94	13.02	18.69	18.12	13.73	1724
Kubanka........	1415	No. Dakota .	11.57	1.95	12.46	74.02	15.8	13.3	70.9	32.51	12.10	11.92	14.44	12.63	1415
	1424	Kansas	11.40	1.58	15.12	71.90	15.0	13.5	71.5	39.30	14.33	16.84	16.69	14.89	1424
Velvet Chaff...	1265	So. Dakota .	11.02	2.15	13.94	72.[illegible]	[illegible]	13.4	70.9	35.76	12.49	15.34	16.48	12.72	1265
Climax..........	1266	So. Dakota .	11.25	2.30	13.72	72.73	13.9	12.7	74.9	34.24	11.95	16.90	16.27	12.54	1266
Minn. No. 171	126[illegible]	So. Dakota .	11.50	2.35	14.61	71.54	15.9	13.3	70.8	37.99	13.43	16.23	18.43	13.19	1267
Fultz............	12.66	So. Dakota.	11.25	2.30	13.72	72.73	13.9	11.2	73.4	[illegible]	11.76	17.77	16.84	11.85	1422
Big Frame.....	1488	Nebraska ..	10.08	1.34	11.47	77.11	13.1	11.8	74.1	27.82	10.00	13.93	15.00	10.57	1488
Wheedling	1490	Illinois	12.91	1.27	10.60	75.22	14.5	11.3	74.2	24.12	8.66	13.72	14.31	9.63	1490
Dawson D. G.	1491	Illinois	13.15	1.25	10.03	75.51	15.8	11.5	72.7	18.88	7.12	12.97	12.25	8.87	1491
K. B. No. 2.....	1492	Illinois	13.08	2.56	9.91	74.45	15.6	13.5	70.9	18.21	6.48	12.78	13.35	8.65	1492

These results show that the chemical composition and other analytical results on these samples are not greatly different from those of Washington wheats grown the same year. The samples from Illinois are noticeably lower in those constituents which are generally recognized as conferring high quality upon wheat and its mill products. The samples from North and South Dakota and Minnesota, the so-called "hard red spring wheat" section show analytical data very similar to that of the best wheats of Washington. Those from the "hard winter wheat" district in Kansas generally show somewhat higher per centages of desirable constituents than the averages for any Washington varieties, while the winter wheats from Nebraska are considerably lower in the same constituents.

Evidence from additional tests on other year's crops must be secured before final conclusions can safely be drawn. It would appear from the results of these tests, however, that so far as the crop of 1906 is concerned, the difference between the so-called "hard" wheats of the Mississippi Valley and the "soft" wheats of this State, is not so great as has been supposed. It has been pointed out, on the other hand, that Washington wheats of the crop of 1906 are richer in protein and yield flour of higher gluten content than those of the preceding years's crop. Should it later be ascertained that the 1906 samples of Eastern grown wheats were lower than they normally are in the constituents, then the real difference between Eastern and Washington wheats is greater than shown by this year's tests. If, however, the Mississippi Valley wheat of the crop of 1906 were above the normal in the same way, or to the same degree that Washington wheats of this season were, there the difference between the two is normally no greater than that found this year.

THE CROP OF 1907

The samples of Washington grown wheats of the crop of 1907 were secured in exactly the same manner as those of the preceding years. The total number of samples received was eighty, representing sixteen different varieties and twenty-four

different shipping points. The full details of the descriptions accompanying the samples are shown in Table IV.

TABLE IV. DESCRIPTION OF SAMPLES—CROP OF 1907

No.	Variety	Grown by	Grown at	County	Bu.pr Acre	condi'n	Test wt per Bu.
2651	Bluestem	....	....	Lincoln	....	pf	60
2656	Little Club	....	....	Lincoln	....	pf	59½
2657	Bluestem	W. A. Nixon	Genesee	Latah, Idaho	[illegible]7	p	60½
2658	Little Club	Geo. Blume	Genesee	Latah, Idaho	35	p	60½
2659	Turkey Red	Clearwater Ranch	Genesee	Latah, Idaho	35	s	59
2660	Klondike	John Magie	Genesee	Latah, Idaho	35	p	62½
2661	Squarehead	Clearwater Ranch	Genesee	Latah, Idaho	35	p	62
2662	Jenkins' Club	J. B. Danies	Genesee	Latah, Idaho	35	sspl	58½
2669	Bluestem	A. Golnick	Anatone	Asotin	30	p	58½
2670	Little Club	A. R. Stein	Anatone	Asotin	30	p	61
2671	Fortyfold	W. C. Halsey	Anatone	Asotin	44	p	62
2672	Turkey Red	Jas. N. Boggan	Anatone	Asotin	40	p	62
2673	Turkey Red	Wm. Newells	Theon	Asotin	....	p	61½
2690	Little Club	....	Kiona	Benton	....	p	61
2703	Bluestem	....	Reardan	Lincoln	....	p	58
2704	Fife	....	Reardan	Lincoln	....	pf	58
2705	Jenkins' Club	....	Reardan	Lincoln	....	p	58⅓
2706	Early Wilbur	....	Reardan	Lincoln	....	p	63
2707	Bluestem	Robt. Baker	Wilbur	Lincoln	35	p	60½
2708	Jenkins' Club	F. Hudkins	Wilbur	Lincoln	40	p	60½
2709	Red Allen	Wm. Gimmel	Wilbur	Lincoln	37	p	61½
2710	Early Wilbur	A. Anderson	Wilbur	Lincoln	40	p	63
2711	Bluestem	R. H. King	Berryman	Walla Walla	....	p	60
2712	Bluestem	F. D. Rinehart	Alto	Columbia	38	p	61½
2713	Little Club	G. Vollmer	Waitsburg	Columbia	40	p	58½
2714	Turkey Red	W. J. Bartges	Waitsburg	Columbia	....	p	60½
2715	Turkey Red	D. W. Tyler	Waitsburg	Columbia	....	p	61
2716	Macaroni	H. H. Vincent	Starbuck	Columbia	....	p	61½
2717	Dale	Wm. Weller	Waitsburg	Columbia	....	p	60

TABLE IV. DESCRIPTION OF SAMPLES—CROP OF 1907—CONTINUED

No.	Variety	Grown by	Grown at	County	Bu. pr Acre	condi'n	Test wt per Bu.
2720	Bluestem	H. Domreese	Waterville	Douglas	....	p	61
2721	Red Allen	John Witten	Waterville	Douglas	....	p	61½
2722	Red Allen	J. H. Goll	Waterville	Douglas	33	p	61½
2723	White Elliott	C. L. Ballard	Waterville	Douglas	35	p	62½
2724	White Elliott	C. W. Hensel	Waterville	Douglas	....	p	62
2725	Bluestem	H. P. Hays	Endicott	Whitman	30	p	59½
2726	Little Club	H. B. Schrieman	Endicott	Whitman	27	p	60
2727	Little Club	Frank Teal	Endicott	Whitman	23	s	56
2728	Fortyfold	L. F. Smith	Endicott	Whitman	26	p	60
2729	Fife	H. B. Schrieman	Endicott	Whitman	27	psm	57
2730	Turkey Red	F. H. Ackerman	Endicott	Whitman	30	p	62
2731	Bluestem	H. M. Pugh	Hartline	Douglas	25	ss	57
2732	Red Allen	D. O. Hughes	Hartline	Douglas	26	p	61
2733	Red Allen	J. J. Pugh	Hartline	Douglas	25	p	61
2734	Red Chaff	G. G. Hughes	Almira	Lincoln	....	ss	57½
2736	Bluestem	D. C. Hayes	Bluestem	Lincoln	32	p	61
2737	Bluestem	....	Harrington	Lincoln	26	s	56
2747	Bluestem	Wm. Silt	Ritzville	Adams	30	p	61
2748	Turkey Red	J. C. Hauschild	Ritzville	Adams	28	p	61
2760	Bluestem	A. N. Huffman	Tekoa	Whitman	....	p	61
2761	Little Club	Leroy Willard	Tekoa	Whitman	....	p	60
2762	Genesee Giant	K. Erickson	Tekoa	Whitman	....	p	59
2763	Bluestem	Joel Howton	Kahlotus	Adams	....	p	59½
2764	Bluestem	B. S. Hastings	Kahlotus	Adams	....	ss	57
2765	Bluestem	John Howton	Kahlotus	Adams	....	bsw	55
2766	Fortyfold	B. J. Williams	Kahlotus	Adams	....	p	60
2767	Fife	Sinclair Bros.,	Kahlotus	Adams	....	p	60
2768	Fife	J. H. Barnes	Kahlotus	Adams	....	sbl	57
2769	Bluestem	J. W. Kliphardt	Connell	Franklin	32	p	59½

TABLE IV. DESCRIPTION OF SAMPLES—CROP OF 1907—CONTINUED

No.	Variety	Grown by	Grewn at	County	Bu.pr Acre	condi'n	Test wt per Bu.
2770	Bluestem		Connell	Franklin	....	ss	57
2771	Fife		Connell	Franklin	....	p	60½
2772	Fife		Connell	Franklin	....	s	56
2773	Turkey Red	Beckley Bros.,	Connell	Franklin	....	p	61
2774	Turkey Red	Wm. Hastings	Connell	Franklin	....	ss	58
2776	Bluestem	G. W. DuBois	Willada	Whitman	25	p	60
2777	Bluestem	E. O. Henderson	Willada	Whitman	20	ss	58
2778	Little Club	F. Michel	Willada	Whitman	....	p	59
2779	Little Club	J. W. Lockhart	Willada	Whitman	....	ss	
2780	Fife	Erickson Bros.,	Willada	Whitman	35	p	61
2781	Sonora	J. F. Chevalier	Willada	Whitman	20	p	61
2782	Bluestem	C. L. Dutcher	Sprague	Lincoln	....	ss	57
2783	Bluestem	J. W. Nixon	Sprague	Lincoln	....	p	59
2784	Bluestem	Theo. Stalp	Sprague	Lincoln	....	p	59½
2785	Bluestem	M. Scheuss	Sprague	Lincoln	....	p	60
2736	Bluestem	Aug. Witt	Sprague	Lincoln	....	pbl	59
2796	Bluestem	Bieman Bros.,	Pine Creek	Okanogan	....	p	63
2797	Bluestem	J. H. Green	Synarep	Okanogan	....	ss	58¼
2798	Bluestem	J. H. Alexander	Synarep	Okanogan	....	p	60
2799	Bluestem	T. T. Taylor	Synarep	Okanogan	....	p	60½
2800	Turkey Red	M. Geyer	Synarep	Okanogan	....	p	60

The harvest of 1907 was remarkable for its cool, cloudy, moist weather in many parts of the state. As a consequence the majority of the samples received were of plump, heavy grain. In some localities, rain fell while the grain was ripe and still standing uncut in the fields, or in the shock. Some of the grain was therefore bleached, and samples representing this kind of grain are marked "Bl" in the column headed "Condition." In certain sections of the state, maturity was so slow that an early frost caught some of the wheat before it was quite ripe. Samples of this grain are marked "F." "Sm" in the same column indicates that the grain was badly damaged by smut, and "W" indicates the presence of considerable foreign weed seeds.

The complete results of the laboratory and milling tests on these samples are shown in Table V.

TABLE V. RESULTS OF TESTS—CROP OF 1907

Variety	Smpl No.	Quality	Analysis of the Wheat				Y'ld of Mill Prdcts			Gluten in Flour		Protein in Mill Pr'dcts			Sample No.
			Moistre	Ash	Crude Prot'n	Carbo. and Oil	Bran	Shrts	Flour	Wet	Dry	Bran	Shorts	Flour	
Bluestem........	2651	Frosted ...	10.16	1.55	11.88	76.41	15.8	12.8	71.4	35.51	10.30			10.37	2651
	2657	Heavy	12.55	1.62	11.36	74.47	16.8	11.7	71.5	27.84	9.81	14.34	14.67	9.86	2657
	2669	Medium ...	11.78	1.64	8.87	77.71	15.5	12.7	71.8	20.27	8.35	9.90	11.00	8.46	2669
	2703	Heavy	13.55	1.62	9.76	75.07	15.9	11.8	72.3	24.03	9.67	12.79	13.50	8.92	2703
	2707	Heavy	13.03	1.58	11.54	73.86	16.3	11.7	72.0	30.96	10.32	15.15	15.30	10.54	2707
	2711	Heavy	11.16	1.55	12.53	74.76	15.6	12.1	72.3	32.05	11.40	15.55	15.29	11.38	2711
	2712	Heavy	11.00	1.65	11.60	75.75	16.0	11.8	72.2	27.02	9.35	14.34	14.79	10.79	2712
	2720	Heavy	11.22	1.92	10.62	76.24	15.4	10.4	74.2	28.80	9.41	13.11	13.20	10.03	2720
	2725	Heavy	10.61	1.70	13.02	74.67	15.3	13.5	71.2	35.41	11.93	16.10	16.63	12.05	2725
	2731	Medium ...	12.29	1.98	12.37	73.36	16.3	12.0	71.7	31.20	10.67	15.97	15.67	11.18	2731
	2736	Heavy	11.04	1.59	10.28	77.09	15.8	12.7	71.5	23.12	8.82	13.26	13.77	9.64	2736
	2737	Light	10.71	1.83	14.43	72.09	16.4	11.7	71.9	37.86	13.80	17.68	16.90	13.50	2737
	2747	Heavy	10.43	1.42	12.96	75.19	16.6	12.0	71.4	32.66	11.35	15.90	15.93	11.57	2747
	2760	Heavy	14.10	1.62	9.63	74.65	15.3	12.9	71.8	22.20	7.85	13.26	13.64	8.78	2760
	2763	Heavy	10.91	1.50	13.12	74.47	16.2	12.5	71.3	35.45	11.87	17.77	15.60	11.84	2763
	2764	Medium ...	11.83	1.41	13.62	73.14	15.0	13.3	71.7	35.75	11.80	17.36	16.50	12.11	2764
	2765	Light	11.45	1.39	13.53	73.63	15.5	13.3	71.2	33.26	12.17	17.82	16.90	12.23	2765
	2769	Heavy	11.19	1.44	11.60	75.77	13.8	12.0	74.2	29.43	10.19	15.14	15.49	10.70	2769
	2770	Medium ...	10.43	1.57	11.64	76.36	16.4	12.7	70.9	28.17	9.94	15.00	14.70	10.40	2770
	2776	Heavy	9.00	2.10	10.43	78.47	15.2	12.3	72.5	23.50	8.53	13.47	14.54	9.21	2776
	2777	Medium ...	8.58	1.83	11.16	78.43	15.6	12.9	71.5	28.61	9.56	14.02	15.35	10.32	2777
	2782	Medium ...	9.54	1.83	11.67	76.96	15.9	12.3	71.8	29.10	9.91	14.58	15.42	10.28	2782
	2783	Medium ...	8.14	1.62	13.02	77.22	16.1	13.3	70.6	32.91	10.82	16.14	15.45	11.67	2783
	2784	Heavy	9.84	1.85	10.14	78.17	15.7	12.7	71.6	23.43	8.56	12.97	13.81	9.09	2784
	2785	Heavy	10.19	1.85	11.23	76.73	15.3	12.5	72.2	26.79	9.41	14.70	14.63	10.03	2785
	2786	Musty......	9.81	1.80	11.54	76.85	14.3	12.1	73.6	25.86	9.42	14.30	14.58	10.30	2786
	2796	Very Heavy.	10.47	1.63	10.57	77.33	16.1	12.8	71.1	25.15	9.15	14.30	14.29	9.56	2796
	2797	Medium ...	10.33	1.88	11.09	76.70	16.2	11.8	72.0	27.10	9.50	14.08	15.00	9.78	2797
	2798	Heavy	10.34	1.98	10.85	76.83	15.3	12.5	72.2	27.00	9.36	13.23	14.84	9.78	2798
	2799	Heavy	10.22	1.92	10.87	76.99	16.3	12.0	71.7	26.06	9.43	13.81	14.16	9.90	2799
	Maximum	....	14.10	2.10	14.43	78.47	16.8	13.5	74.2	37.86	13.80	17.82	16.90	13.50	
	Minimum	......	8.14	1.39	8.87	72.09	13.8	10.4	70.6	20.27	7.85	9.90	11.00	8.46	
	Average	....	10.83	1.69	11.56	75.84	15.7	12.4	71.9	29.21	10.09	14.16	14.39	10.47	

TABLE V. RESULTS OF TESTS—CROP OF 1907—CONTINUED

Variety	Smpl No.	Quality	Analysis of the Wheat				Y'ld of Mill Prdcts			Gluten in Flour		Protein in Mill Pr'dcts			Sample No.
			Moistre	Ash	Crude Prot'n	Carbo. and Oil	Bran	Shrts	Flour	Wet	Dry	Bran	Shorts	Flour	
Little Club.....	2656	Heavy	11.60	1.65	10.51	76.24	15.2	12.2	72.6	28.07	9.58	14.39	14.16	9.38	2656
	2658	Heavy	11.64	1.85	9.53	76.98	15.0	12.7	72.3	24.29	8.52	11.49	13.16	8.46	2658
	2670	Heavy	12.58	1.73	9.18	76.51	15.3	13.3	71.4	24.65	8.50	11.45	12.69	8.34	2670
	2690	Medium ...	10.20	2.15	11.57	76.08									2690
	2713	Medium ...	10.30	1.92	11.78	76.00	14.8	11.8	73.4	31.06	10.77	13.73	14.74	10.61	2713
	2726	Heavy	10.48	1.62	11.09	76.81	14.2	11.8	74.0	27.49	9.42	14.79	14.34	10.15	2726
	2727	Light	11.32	1.66	10.62	76.40	15.2	12.8	72.0	26.92	9.13	13.64	14.79	9.58	2727
	2761	Heavy	13.05	1.77	8.65	76.53	14.2	12.5	73.3	20.74	7.50	12.97	11.53	7.83	2761
	2778	Medium ...	8.68	1.75	12.00	77.57	14.6	12.4	73.0	30.17	10.00	15.39	15.72	10.57	2778
	2779	Light	8.83	1.53	13.52	76.12	15.0	12.5	72.5	38.15	12.51	17.36	17.18	12.57	2779
Red Chaff......	2734	Medium ...	12.12	1.73	9.29	76.86	15.6	10.3	74.1	21.55	7.69	12.51	13.73	9.05	2734
Jenkin's Club..	2662	Light	13.53	1.81	8.26	76.40	15.8	13.1	71.1	19.59	6.79	10.50	11.73	6.98	2662
	2705	Light	13.84	1.59	10.45	74.12	15.7	12.7	71.6	29.27	10.83	14.06	14.53	9.63	2705
	2708	Heavy	12.87	1.55	9.60	75.86	15.4	12.0	72.6	26.95	9.15	12.26	13.16	8.95	2708
	Maximum		13.84	2.15	13.52	77.57	15.8	13.3	74.1	38.15	12.51	17.36	17.18	12.57	
	Minimum		8.68	1.53	8.26	74.12	14.2	10.3	71.1	19.59	6.79	10.50	11.53	6.98	
	Average		11.49	1.75	10.43	76.33	15.1	12.3	72.6	26.74	9.23	13.34	13.94	9.40	
Turkey Red...	2659	Medium ...	10.77	1.60	8.40	79.23	16.0	12.6	70.4	14.70	5.48	10.20	12.09	7.69	2659
	2672	Heavy	11.00	1.53	8.40	79.07	16.3	11.7	72.0	17.83	6.70	9.70	10.52	8.09	2672
	2673	Heavy	10.50	1.75	9.58	78.17	16.3	13.0	70.7	24.99	8.66	10.92	11.66	9.06	2673
	2714	Heavy	10.04	1.72	9.18	79.06	16.3	12.3	71.4	24.72	8.66	10.87	12.75	8.42	2714
	2715	Heavy	11.45	1.70	9.09	77.76	16.8	12.0	71.2	22.85	8.38	10.94	11.79	8.40	2715
	2730	Heavy	11.04	1.51	12.11	75.24	16.4	12.0	71.6	33.23	11.26	13.97	13.85	11.28	2730
	2748	Heavy	11.10	1.[illegible]	11.90	75.38	16.5	12.2	71.3	34.26	11.60	14.16	12.97	11.79	2748
	2773	Heavy	8.77	1.58	12.43	77.12	16.1	12.4	71.5	33.43	11.37	14.16	13.68	11.90	2773
	2774	Heavy	9.27	1.53	12.1[illegible]	77.09	16.8	13.1	70.1	29.26	10.61	14.49	13.11	11.34	2774
	2800	Heavy	10.00	2.35	10.[illegible]	[illegible].10	15.3	12.9	71.8	27.49	9.73	12.00	12.97	9.70	2800
	Maximum		11.45	2.35	12.43	79.23	16.8	13.1	72.0	34.26	11.60	14.49	13.85	11.90	
	Minimum		8.77	1.51	8.40	75.24	15.3	11.7	70.1	14.70	5.48	9.70	10.52	7.69	
	Average		10.39	1.69	10.38	77.12	16.3	12.4	71.2	26.28	9.35	12.14	12.53	9.77	

TABLE V. RESULT OF TESTS—CROP OF 1907—CONTINUED

Variety	Smpl No.	Quality	Analysis of the Wheat				Y'ld of Mill Prdcts			Gluten in Flour		Protein in Mill Pr'dcts			Sample No.
			Moistre	Ash	Crude Prot'n	Carbo and Oil	Bran	Shrts	Flour	Wet	Dry	Bran	Shorts	Flour	
Fife	2704	Medium ...	12.65	1.64	9.22	76.49	15.2	12.8	72.0	20.32	8.62	10.79	12.74	8.40	2704
	2729	Light	12.09	1.40	10.85	75.66	16.4	12.9	70.7	25.54	8.98	13.64	14.11	9.59	2729
	2767	Heavy	10.28	1.38	9.63	78.71	15.2	12.5	72.3	24.40	8.42	11.97	13.38	9.35	2767
	2768	Light	10.52	1.50	12.40	75.58	15.1	12.7	72.2	33.25	11.62	15.14	15.14	11.57	2768
	2771	Heavy	9.95	1.50	12.57	75.88	16.2	12.4	71.4	35.17	12.31	15.39	15.81	11.48	2771
	2772	Light	9.41	2.02	14.43	74.14	15.8	12.0	72.2	35.33	11.67	17.17	16.00	13.10	2772
	2780	Heavy . . .	8.06	1.50	12.60	77.86	15.5	12.2	72.3	32.11	10.81	15.97	15.97	11.20	2780
	Maximum	......	12.65	2.02	12.60	78.71	16.4	12.9	72.3	35.33	12.31	17.17	16.00	13.10	
	Minimum	......	8.06	1.38	9.22	74.14	15.1	12.0	70.7	20.32	8.42	10.79	12.74	8.40	
	Average	....	10.42	1.56	11.69	76.33	15.6	12.5	71.9	29.48	10.34	14.29	14.73	10.67	
Red Allen......	2709	Heavy	12.47	1.53	12.87	73.13	14.8	11.3	73.9	35.26	11.92	16.74	16.19	11.78	2709
	2721	Heavy	11.34	1.62	10.83	76.21	15.0	12.2	72.8	27.70	9.18	14.16	13.94	9.78	2721
	2722	Heavy	12.18	1.33	11.84	74.65	15.4	12.3	72.3	33.26	11.04	15.13	15.56	11.09	2722
	2732	Heavy	11.79	1.85	10.68	75.68	15.0	12.7	72.3	25.07	8.97	13.77	13.94	9.59	2732
	2733	Heavy	12.34	1.79	10.70	75.17	15.0	11.5	73.5	25.91	9.01	13.97	14.54	9.64	2733
Forty Fold	2671	Heavy	10.10	1.48	8.82	79.60	15.6	12.7	71.7	18.57	6.65	10.83	12.35	8.18	2671
	2728	Heavy	12.28	1.68	10.20	75.84	15.0	13.7	71.3	22.70	7.88	12.46	14.16	9.30	2728
	2766	Heavy	10.85	1.55	13.25	74.35	16.0	12.8	71.2	35.18	12.24	16.90	17.73	12.02	2766
Early Wilbur..	2706	Heavy	13.16	1.36	12.14	73.34	14.6	12.5	72.9	35.32	12.23	15.72	15.30	11.54	2706
	2710	Heavy	12.46	1.59	9.70	76.25	15.5	12.7	71.8	25.65	8.95	12.09	13.23	9.15	2710
White Elliot...	2723	Heavy	11.68	1.50	10.15	76.67	14.3	12.8	72.9	26.23	8.96	13.53	13.73	9.53	2723
	2724	Heavy	13.45	1.46	11.23	73.86	16.3	12.3	71.4	30.33	10.11	15.60	15.67	10.23	2724
Macaroni........	2716	Heavy	9.86	1.95	15.36	72.83	14.2	12.9	72.9	42.98	15.71	15.72	16.40	14.92	2716
Genesee Giant	2762	Medium ...	11.82	1.65	8.62	77.91	16.0	10.7	73.3	17.72	7.36	10.95	12.09	8.03	2762
Sonora..	2781	Heavy	9.24	1.73	9.97	79.06	15.0	12.8	72.2	22.88	8.14	13.23	13.50	8.57	2781
Dale..............	2717	Heavy	11.05	1.76	13.73	73.46	15.8	11.8	72.4	43.90	15.12	18.25	16.50	13.30	2717
Klondyke	2660	Heavy	11.53	1.62	10.79	76.06	15.6	12.3	72.1	28.05	9.90	13.23	11.63	10.03	2660
Squarehead ...	2661	Heavy	11.17	1.82	11.37	75.64	16.2	12.0	71.8	28.55	10.40	13.86	14.91	10.32	2661

The results recorded in the table show that the whole crop of 1907 averages lower in protein, or gluten producing material, than the crop of 1906, the difference being undoubtedly due to the cool, moist, cloudy weather during the harvest season of 1907 as compared with the hot, dry harvest weather of 1906. It is believed that the actual difference between the two crops is greater than that shown in the two tables (Tables II and V.), because of the fact that most of the samples of the crop which were sent to the Station were of No. 1 grade, whereas a very large percentage of the total crop of the state for that year was lighter grain of No. 2, or even No. 3, grade. The instances in which heavy and light grain were received from the same locality and tested side by side in the laboratory show, as has been pointed out, that the lighter grain was richer in protein and yielded flour with higher gluten content. Hence, if as large a proportion of the samples tested had been light weight grain, as was the proportion of light grain in the whole crop of the state, the average percentage of these constituents in the year's samples would doubtless have been considerably higher than those actually obtained.

The comparisons to be drawn from the two tables do show, however, the variations in the similar grade, or plumpness, of grain grown in the two seasons in the same districts and afford very interesting evidence upon the relation of climate to the chemical composition of crops. The comparison between samples of the same grade of any given variety, grown during the same season, show what variations may be caused by different conditions of growth. But in such case it is impossible to say how much of the observed variations may be due to difference in soil and how much to climatic differences. But the comparison between crops grown in the same locality, on the same soils, in different years, eliminates the possibility of soil influence, at least so far as chemical composition of the soil is concerned, and limits the causes for the differences found to climatic influences, such as temperature, sunshine, moisture supply, etc. It appears from the analytical figures already obtained in this study, and from similar results obtained by other investigators, and the chief, if not sole factor in determin-

ing the comparative chemical composition of wheat of the same variety grown in different localities is the climatic conditions during harvest, and that differences in the compositon of the soil have very little, if any, effect upon the quality of the grain, except in so far as the soil affects the moisture supply of the plant. In comparisons between different varieties, the tendency of each variety to produce grain of a certain quality must, of course, be taken into account. But varietal differences seem to be less marked than differences within the same variety caused by variations in the climatic conditions under which the grain is ripened.

Investigations are in progress at this station to determine the effect of each of the several factors which go to make up climatic influence, such as relative temperature, cloudy weather or direct sunshine, humidity of the air, moisture supply in the soil or rainfall, etc., upon the composition of the wheat; and also the stage of the plants development at which these influences exert the strongest effect upon the quality of the ripe grain. The results of these investigations will be presented in a later bulletin.

AVERAGE COMPOSITION OF WHEATS OF THE CROPS OF 1905, 1906 and 1907

It is very desirable that the full five years' investigation shall be completed before definite conclusions as to the comparative composition of the different varieties of wheat grown in this state are drawn. But the results of the three years' tests which have been completed, representing as they do one nearly normal, one usually hot and dry, and one cool, moist, harvest season may be summed up and certain average figures presented which will be of general interest. Accordingly some of the data from the entire number of samples have been received, has been compiled and the averages for the moisture and protein content of the grain, the yield of flour, and the wet gluten test of the flour, are presented in Table VI.

TABLE VI

AVERAGE OF TESTS FOR THE THREE CROPS
1905–1907 INCLUSIVE

VARIETY	No. of Samples Tested	Moisture Per Cent	Crude Protein Per Cent	Yield of Flour Per Cent	Wet Gluten Per Cent
Macaroni	9	9.94	12.41	72.0	32.77
Bluestem	76	10.88	12.34	71.7	30.98
Turkey Red	28	10.40	11.96	71.2	30.68
Sonora	7	12.00	11.78	72.2	30.29
Jones' Fife	30	10.07	11.67	71.8	26.25
Red Allen	12	11.75	11.56	72.7	30.29
White Amber	6	12.10	11.01	71.1	26.97
Fortyfold	15	11.06	10.96	72.5	23.11
Club	43	10.93	10.68	72.5	25.82
Red Russian	12	10.67	9.77	71.2	22.86

In this table the several varieties are arranged in the order of their average protein contents for flour making. Sonora wheat is largely used for the manufacture of bread foods. Macaroni wheat is not yet used in any quantity in this state. The comparatively high protein content of the few samples which have been analyzed indicate that in this state it conforms to its usual high gluten qualities. It is, therefore, a very valuable wheat for food purposes. and may be largely used in this country for the manufacture of macaroni and similar food products. Millers are not yet successful in producing as high a quality of flour from this variety of wheat as its high gluten content would seem to indicate to be possible. It is possible that further study of this matter may reveal a proper system of milling whereby a flour of good baking quality may be made from this high gluten wheat.

It should not be understood that the averages presented in this table necessarily represent the real relative composition of these several varieties of wheat as grown in this state. They do, probably, acurately represent the comparative values of these varieties for milling purposes, so far as the three years, 1905 to 1907 are concerned. At least, this may be assumed to be true for the five varieties of which twelve or more samples were submitted to complete tests.

A lack of sufficient laboratory force to handle the rapidly increasing volume of analytical work of the Department, has made it impossible to carry out such elaborate sponge and baking tests on the samples collected during these two years as were originally planned, and put in operation upon a part of the samples of the crop of 1905. A student of the Washington State College did make some baking tests on some of the samples of the crop of 1906, using both some of the Washington-grown and some of the Eastern-grown wheats. He was absolutely inexperienced in the methods of bread-making and in the use of the standard apparatus for this purpose, however, and his results were so erratic and so impossible to correlate with any other observed properties of the several flours or wheats from which they were made, that it seemed best to discard them. Their publication would only lead to confusion and possibly to wrong conclusions, and they will, therefore, be omitted from this report. It is hoped that increased assistance may be available for the further investigations of this series and that complete sponge and baking tests of at least a considerable proportion of the flours which are manufactured from the wheats analyzed may be made. Some indications of a probable influence of certain mineral constituents of the flour, especially the soluble phosphates, upon the physical quality of the gluten and the baking strength of the flour, have been discovered and are being investigated. These will be fully discussed in later reports of these investigations.

The author of this bulletin desires to express here his indebtedness to the many citizens of the state who have assisted in collecting samples; to Mr. C. W. Lawrence, Cerealist of this Station, for the milling of the wheat; and to Mr. H. R. Watkins, formerly Assistant Chemist of the Station for a large part of the analytical work reported in this bulletin.

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Supo

The State College of Washington
AGRICULTURAL EXPERIMENT STATION

PULLMAN, WASHINGTON

DEPARTMENT OR HORTICULTURE

CHERRIES IN WASHINGTON

By W. S. THORNBER

BULLETIN No. 92
1910

Figure 1. A well-cared-for Cherry Orchard.

All bulletins of this station sent free to cittzens of the State on application to director

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INTRODUCTION.

During the last ten or twelve years the cherry industry of the Northwest has made rapid progress and now is ranked as one of the leading horticultural industries of this state. A few sections have become famous for their cherries; others have failed. There are many valleys yet to be tried.

Only recently have the possibilities of this crop as a commercial proposition been realized. With the coming into use of the refrigerator car for soft fruits, the invention of the Pony refrigerator, the erection of canneries and the origin of several particularly firm, good shipping, high quality western varieties the industry received an impetus that placed it at once with the foremost fruit crops.

With the invention of a cheap method of pitting, especially sour cherries, another profitable and wide field of cherry growing will open to the Northwest. These varieties grow exceedingly well and produce abundantly in practically all parts of the Northwest but there is a very limited market for them in the fresh state and labor is entirely too high for hand pitting for drying purposes.

According to Commissioner F. A. Huntley's report for the year ending 1908, there are 10,688 acres of cherries in the State of Washington alone and many more acres are being prepared for planting; and the wholesale average market prices for "Spokane, Seattle and Tacoma" were $1.25 to $1.50 per ten-pound box in May to from 50 cents to $1.25 per ten-pound box in August. During the season of 1908, the first week in August $2.00 per box was paid for the best grades, the highest average for any week of the season.

The sweet cherry as a crop is a very heavy producer in most parts of the state. The only serious drawback is late spring frosts and for this reason every precaution possible should be taken to select as nearly as possible frost free locations for the growing of this crop. Smudges and orchard heaters are being employed and in many sections will be of great value, but the early precaution is by far the safest.

Location.

The cherry as a tree is generally hardy and readily adapts itself to varied conditions. However, it is extremely susceptible to early fall injury if caught by a hard freeze before the new wood has had an opportunity to ripen thoroughly or mature. This injury is frequently called "winter killing," but in reality is due to poor location, unsatisfactory site or late summer or fall growth.

Probably the most critical time in cherry culture is that period preceding, during and immediately following the blooming of the trees. Heavy losses occur annually during this time of the year which possibly might have been avoided if proper judgment had been used in the selection of the site or location for the orchard. Cherry trees bloom from two to eight days later on northern slopes than they do on southern slopes and are always less subject to frost injury on rolling, slightly elevated or sloping than on flat lands. Good atmospheric drainage is one of the essentials to successful cherry culture.

Soil.

Soil: The cherry can be profitably grown on a variety of soils, but for long life of tree and large, regular crops it should have a rather dry sandy loam to light clay loam, rich in mineral plant foods but poor in nitrogen. The subsoil should be porous, well drained and neither clay hard pan nor dry gravel. A stiff clay soil rich in nitrogenous plant food produces a woody, rarely productive, short lived tree; while a poorly drained soil rarely or ever produces a healthy, productive tree. The cherry is a heavy feeder and should be encouraged in growth while young, but wood growth should be discouraged in the old or bearing tree.

A first class cherry soil should contain abundance of free moisture during the early spring months and up to the time of the ripening of the fruit; afterward only enough moisture to keep the tree growing slowly or keep the wood plump.

Planting.

Distance: The variety, soil, climate and rainfall or irrigation all combine as factors in governing the distance apart that

trees should be planted. The sweet cherry on rich soil. with a reasonable amount of moisture, requires from thirty to forty feet; while sour cherries under the same conditions will not require more than twenty to twenty-five feet. On the rich moist soils of Western Washington, the sweet cherry should be given plenty of room for full development and will require from thirty-five to forty feet. The irrigated valleys with light sandy soils and more or less of a scarcity of nitrogen will produce good cherries at from twenty-five to twenty-eight feet; while sweet cherries on the rich uplands of Eastern Washington should have from twenty-eight to thirty-two feet in order to be sure of sufficient moisture.

Heavy fruit production at the expense of wood growth is common in the valleys, while the reverse is true in Western Washington.

The cherry should always be planted alone and never as a filler or with a filler for any other orchard tree since it requires an entirely different method of cultivation. It is a late spring and early summer grower and matures its crop very early in the season and should naturally take the remainder of the season for the development of fruit spurs and buds and the maturing of the wood. It is wrong to expect it to maintain a growing activity for a period as long as the apple or peach and so for this reason should never be planted with these trees.

Before planting the trees the soil should be thoroughly subdued, properly graded if irrigation is necessary and placed in perfect surface tillage.

It matters little whether the square or hexagonal plan be used. Each has its advantages. The more important advantage of each is that the square places the rows a little farther apart; while the hexagonal permits the planting of from six to eight trees more per acre.

Time: In sections where spring comes on very early, the winters are mild, and rain continues until late in the season so that the working of the soil is retarded, fall planting may be practiced to advantage, providing the soil can be properly prepared and well ripened stock be secured. In practically all other sections of the state and especially where there is danger of very cold winter weather, early spring planting is best for

cherry trees. Secure the stock in the fall, carefully heel in near to where it is to be planted, cover the tops if necessary and plant as soon as the soil can be properly worked in the spring.

Method: Dig the holes wide enough so that the roots will go in without crowding, and deep enough so that the transplanted tree will stand from one to two inches deeper than it formerly stood in the nursery. Prune back all bruised or broken roots with a sharp pruner or knife, cutting in such a manner so as to have the cut surfaces rest on the bottom of the hole. Lean the top slightly toward the south or southwest if the prevailing winds come from that direction; otherwise plant straight or at least never lean the tree away from the two o'clock sun or there will be danger of sun scald. Fill the hole from one-third to one-half full of moist, rich soil, or at least cover the roots, and tramp it until firm. Fill the remainder of the hole with loose earth, tramp lightly and leave the top smooth and level; if planting in the spring, but slightly high, if planting in the fall. If water is used at all in the transplanting of trees, it should be applied to the holes the day before planting and permitted to soak away thoroughly before being disturbed unless it is used to firm the soil instead of so much tramping, as is commonly practiced in the irrigated sections. And then as soon as the surface dries it should be gone over with an iron rake and carefully loosened up or leveled as is necessary.

Trees: First class one year old trees are best for planting. However, low headed two year old trees may be satisfactorily used provided they are not overgrown and their root systems are good. A one year old tree is easier to transplant, it can be headed as desired and usually develops into a better and longer-lived tree than an older one.

Propagation and Stocks.

The greatest care possible in the cutting of bud sticks for the propagation of a stock of cherry trees should be exercised. Only vigorous, healthy trees should be propagated from and never under any condition should a diseased or shy bearer be used as a bud stick producer. The average sweet cherry tree

is normally healthy and productive, but it is not difficult to find weak, diseased, or unproductive strains or individuals of our most common sorts.

It is better to propagate from mature bearing trees than young growing trees as the stock tends to come into full bearing earlier and produce firmer, better fruits.

Cherries may be grown on a number of different stocks or roots, but the more common ones are Mahaleb, a wild species from southern Europe and Mazzard, a wild sweet cherry also from Europe, producing small, worthless fruit. The Mahaleb makes the best stock for the Kentish or sour cherry and, while commonly used is not entirely satisfactory for the sweet varieties.

It is hardier and does better than the Mazzard on dry and unsatisfactory soil, but in climates similar to ours the Mazzard produces the better long-lifed tree of the two. The Mazzard is more difficult to bud upon and the trees are harder to transplant, but even with these disadvantages it is by for the more satisfactory root for the sweet cherry.

Top Working —In sections where the body of the tree of certain varieties tends to suffer severely from sun scald, cherry canker and gumosis troubles, it is frequently advantageous to top work these varieties onto some resistant, hardy variety or species and thereby avoid this difficulty. The May Duke, Late Duke, Mazzard and Native Western cherries all make excellent stems upon which to work the sweet cherry while the Mahaleb makes an excellent trunk for the sour sorts. The top working may be done the same as for apples by either side or cleft grafting; or, better yet, by budding. If grafting is employed it must be done very early in spring while the buds of both scion and stock are still dormant.

Cultivation.

Whatever may be the treatment of the old bearing orchard the young cherry orchard should receive nothing but the very best of clean culture from the time it is planted until it is three to five years old. The grass or mulch system is probably

all right for the old tree but when it is necessary to produce wood growth and frame work nothing can do it like clean culture. The young orchard can be advantageously cropped for the first few years without injuring the trees in the least, providing cover crops can be sown or cultivation or irrigation can cease by the middle of August or at the latest by the first of September. The cropping of the young orchard where no cover crops are used produces a better and more developed growth than clean culture alone.

The cultivation of the bearing orchard should start in the spring just as soon as the soil is ready to work, if no cover crops are used, by plowing or disking and immediately pulverizing or clod mashing and harrowing until the surface is firm and smooth. After once getting the soil in first class shape, harrow or surface cultivate every ten days or two weeks and after every rain until the middle of July to first of August when a cover crop should be sown to take up the surplus moisture, temporarily appropriate the available plant food and cause the newly made wood to ripen up thoroughly before winter.

If the trees have been making a poor, unsatisfactory growth the cover crop should be vetch, Canada peas or Crimson clover (preferably Hairy vetch), but if the growth is good or the tendency is toward wood production at the expense of the fruit, then the cover crop should be fall rye or winter wheat for the purpose of checking growth and adding humus to the soil.

If irrigation is practiced, it must not be overdone late in the season on bearing trees, nor should any water be applied to the trees after the fruit begins to color and until it is harvested, or the quality of the fruit will be materially lowered and its ability to keep and ship very seriously injured.

The cherry blossoms very early in the spring, matures its crop in June or July and should have from then until fall to develop fruit buds and ripen its wood. A bearing tree

should not be permitted to make a heavy summer growth. This is always at the expense of the future crop. The fruit buds which produce the largest and best fruit are developed during the preceding June and July and not late in the fall or just before they blossom in spring.

Pruning.

During the first four years of a young cherry tree's life in the orchard it should be carefully, systematically and regularly pruned. By this time it should be large enough and its frame work so well developed that the future pruning would consist largely of the removal of dead, diseased, broken or crossed limbs and an occasional heading back or thinning out of the fruiting wood. Pruning for the production of wood after a tree starts to bear should not be necessary as there is a relationship existing between the amount of wood produced and the size of the crop borne, in the case of most varities of cherries.

How to Prune—The first and most essential pruning of a cherry tree should take place just previous to the beginning of its second year's growth. When one year old trees are planted in the orchard, immediately after transplanting is a good time to give it this pruning. All lateral branches should be cut off close and the top headed back to from 24 to 36 inches from the ground. The purpose of this pruning is to establish a low headed spreading tree rather than a high upright tree. The young tree will require no further pruning until the beginning of the third year's growth unless a very strong sprout springs from the root or on the main stem six inches or less from the ground, necessitating immediate removal.

At the beginning of the third year's growth from three to five of the best branches should be selected to form the frame work of the tree. The remainder should be cut off and those headed back to from one-third to one-half of their original length, cutting to outer buds always and maintaining the most central one as a leader, which should be from four to six inches longer than the rest. These branches should be selected with special reference to their position on the main stem and

to one another. They should have wide angles, no two should be opposite and be as far apart as possible on the main stem.

The pruning for the fourth and fifth year's growth should be very much the same as for the third, using special care to thin the tops and cut back in such a manner as to spread the top as much as possible. After this only the necessary pruning should be done, as heavy pruning tends to produce wood growth which is not at all desirable in bearing trees.

When to Prune—The pruning of young growing trees should be done late in the winter or early in the spring, but never early in the winter as there is a strong tendency for the best results in our experiments show that pruning immediately after the crop has been harvested gives more favorable results. This, in reality, amounts to summer pruning and tends to check growth as well as expose all prospective fruits spurs and their leaves to the sun light which are very desirable features.

Harvesting and Marketing.

Western methods of harvesting and marketing the cherry like other horticultural crops has revolutionized the industry, and while occasionally yet we see a man clawing his fruit from the tree, as a general rule it is carefully picked, neatly packed and placed upon the market in probably the most satisfactory manner.

For long distance shipping the light colored sorts should be picked soon after they begin to color and the dark ones long before they are black and juicy. They must not be poured from one receptacle to another or permitted to become bruised in any manner.

They should be packed immediately after picking, precooled and shipped at once, one day in the life of a cherry frequently means the difference between a very satisfactory or a very unsatisfactory price in eastern markets.

The western ten pound box and four to six box carton make the ideal way to handle either in car load lots or by express in small quantities.

Gumosis.

The much dreaded gumosis of the cherry is neither an insect trouble nor a plant disease, but is a condition of the tree

resulting from one or more unfavorable conditions under which the trees are compelled to grow. Its first appearance is usually noticeable in the toughening or dying of the outer bark on the tree and later in small patches or quantities of gum or juice oozing out of the cracks or breaks in the bark. As time passes on, this usually grows worse, fungi, producing canker enter into these cracks or breaks in the bark, borers find a ready entrance to the wood and sooner or later the tree becomes girdled, unfruitful and finally dies, frequently requiring three to five years to destroy an apparently thrifty tree.

Any of the following conditions will cause gumosis, however where one condition exists others are generally found.

1. Poor soil drainage or too wet land.

2. Strong late fall fall growth, followed by fall or winter injury.

3. Late summer tillage.

4. Root injury, caused by crown gall, woolly aphis, too deep cultivation or winter freezing.

5. Repeated injuries from the single-tree or cultivator handles.

6. A severe attack of aphis, borers or slugs.

7. Too heavy spring pruning of the bearing trees.

8. A hard late spring frost that kills leaves, blossoms, etc.

9. A severe check of growth caused by over irrigation, under irrigation or any natural cause.

In the treating of gumosed trees the essential thing is if possible, to remove the difficulty. If the bark is dry and tough, it should be softened by a good coat of whitewash or a thorough scrubbing with a stiff brush and strong soap suds. It is sometimes advantageous to slit the outer bark on two or three sides of the trunk or large limbs, with the point of a penknife. This should be done during June and not deep enough to injure the inner bark or the cure will be worse than the disease.

If the gum has already started to ooze out and harden, cut away all patches, at the same time removing any dead,

injured or diseased bark, cleanse with strong bordeaux mixture and when dry, coat over with orange shellac or lead paint. A large percentage of the trees can be cured in this way and the lives of all greatly lengthened even though not cured.

VARIETIES.

The following fruit descriptions and notes were made from fruit as it grew in the Experiment Station orchard and shows in many instances interesting variations as to shape, quality productivity, and general behavior of these varieties, as compared with the same varieties in similar reports from Eastern stations.

Dukes and Morellos.

Baender —A dark red, medium to large, roundish to slightly flattened cherry with a heavy, long stem and long, smooth pit. The skin is thin and tender. The flesh is firm, meaty, slightly stained and has a rich acid flavor. A very pretty fruit, ripening from the 25th of July to the 10th of August.

The tree is medium sized, roundish, upright, with erect branches and a small amount of light green foliage free from aphis and disease. A very light yielder of the sour cherry group. Not adapted to eastern Washington conditions.

Bessarabian—Introduced from Russia in 1885 by Prof. Budd. A medium sized purple red, roundish, oblate to heart-shaped fruit with a long, slender stem; small, round stone; thin, tender skin and a meaty, deeply stained, juicy flesh. The fruit is of good quality, of a rich acid flavor when ripe, but rather astringent if picked before it is well ripened on the tree. It ripens from the 12th to the 20th of july and if not disturbed, it hangs to the tree until October.

The tree is a large, upright, round topped one, with long, slender branches and narrow but firm croches. It has an abundance of dark green foliage practically free from insect pests and plant diseases. It has produced three medium to light crops and two big crops during the past five years. One of our most attractive, but not profitable, sour cherry trees.

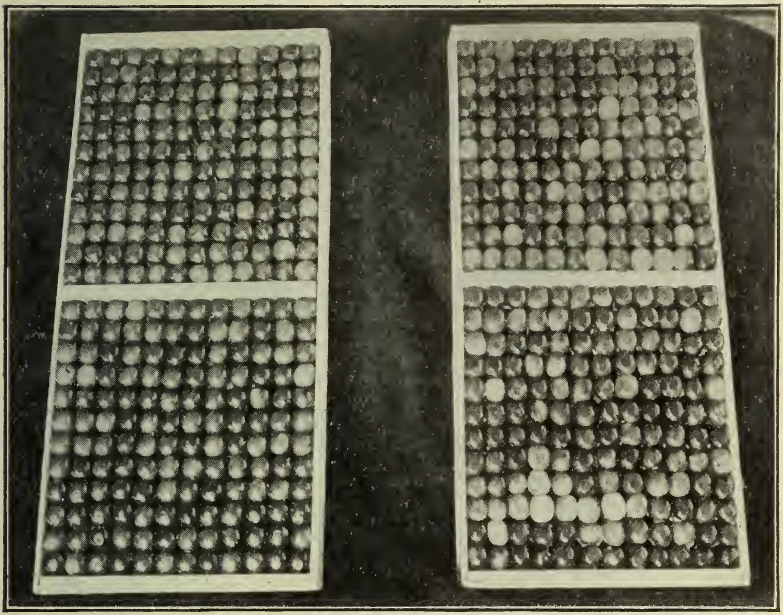

Fig. 2. A Good Commercial Pack, Very Commonly Used in Pacific Northwest.

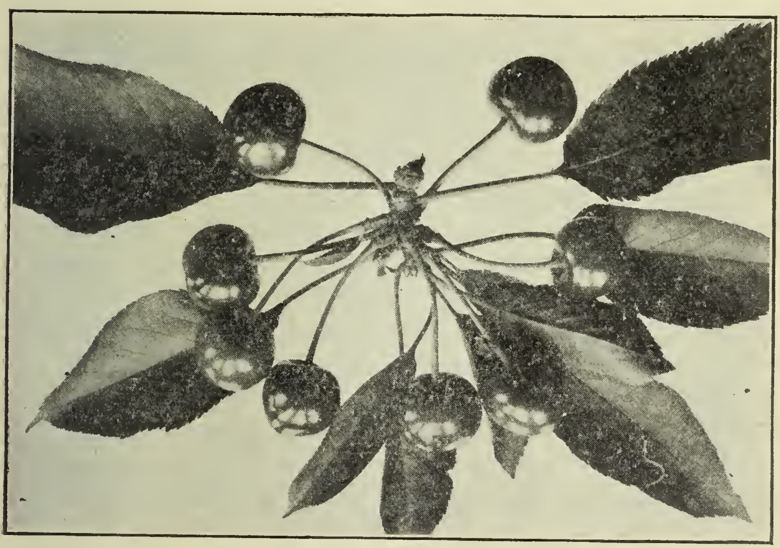

Fig. 3. Olivet. Our Best Sour Variety, One-third Natural Size.

Brusseler Braune—Introduced from Russia, in 1883, by Prof. Budd. A dark to purple red, heart-shaped to round fruit with a heavy, long stem, a large long stone, thin, tender skin and a fine grained, meaty, deeply stained, juicy flesh. When ripened on the tree it is of good quality and has a rich, very pleasant sub-acid flavor. It ripens from the 25th of July to the 10th of August and clings well to the tree.

The tree is a small, low, spreading, opentopped tree with strong horizontal branches and numerous short, recumbert, slender twigs. The foliage is sparse, light green and while free from insects and plant diseases is not at all healthy looking. During the past five years it has produced three light crops, one fair crop and one large one. Not adapted to eastern Washington conditions.

Budd 533—Probably a seedling of a Russian sort sent out by Prof. Budd. A very large, dark mottled red, roundish heart-shaped fruit with a thick, short stem, large round stone, thin, tough skin, and a firm, yellow, astringent, slightly stained flesh. The fruit is of fair quality with a slightly sub-acid flavor and ripens from the 5th to the 25th of July, dropping soon after ripening.

The tree is a small, round-topped tree with slender recumbent branches, good, strong crotches and only a few leaves, mostly on tips of the branches; a light yielder of very large fruit. Not adapted to our conditions.

Cerise de Ostheim—Of Russian introduction. A small to medium sized, dark purple red, roundish oblate fruit with a long slender stem, small round stone, thick, tender skin and a firm, juicy, meaty, deeply stained flesh. The fruit is of good quality and has a rich sub-acid, almost sweet, flavor when dead ripe. It ripens from the 10th to 20th of July and frequently hangs on the tree until September.

The tree is a small, round headed one with strong, horizontal branches and slender, pendant twigs. The foliage is light green, sparse and not characteristic of a strong, sour cherry tree. During the past five years it has produced two light crops; two medium crops and one heavy crop. Neither large enough nor productive enough to be of commercial value.

Fig 4. Late Duke. One of Our Best Hardy Cherries. One-half Natural Size.

Double Natte—Introduced from Russia. A medium sized, dark purple red, oblate to heart-shaped fruit with a very long stem, roundish lop-sided stone, thin, tender skin and a light red, soft, meaty flesh of good quality and rich, pleasant, acid flavor. It ripens from July 10th to the 20th, but remains in good condition upon the tree until September, or even later.

The tree is large, vigorous, compact and rather flat topped. The branches have strong crotches, are horizontal and have numerous pendant twigs. The foliage is dark green, abundant, clean and healthy. During the past five years it has produced two light crops; one medium crop and two very large crops. Not considered valuable in eastern Washington.

Dyehouse—First found growing on the grounds of Mr. Dyehouse, of Lincoln County, Kentucky. A rather small, bright red, roundish oblate cherry, with a small round stone, short, heavy stem, thin tender skin and a soft, juicy flesh. It ripens from the 20th to the 28th of July and remains in good condition upon the tree for two or three weeks.

The tree is a small, round topped tree with slender, willowy branches and an abundance of dark green leaves which are practically free from all kinds of insect pests and plant diseases. While our trees of this variety are still young, they give promise of being a first class variety for commercial planting. A very heavy annual bearer.

Early Morello—Imported from Russia by Prof. Budd, in 1883. A medium to small, bright red mottled with dark crimson, roundish oblate fruit with a rather short stem, small round stone, thick tender skin and a firm juicy, yellow flesh. It is of fair quality and has a brisk acid flavor. It ripens from the last week in June to the first week in July, but hangs on the tree until the first of September.

The tree is a large, round topped, spreading, with long strong, horizontal branches and numerous slender twigs. Its foliage is rather thin, of dark green color, but free from insects and plant diseases. During the past five years it has produced three heavy crops and two medium sized crops. Its soft small, juicy fruit makes it unprofitable for commercial use.

Early Richmond—Introduced from Europe. A medium sized, bright red, roundish oblate fruit with a short, thick stem, very small round stone, thin, tender skin and a soft, juicy flesh. The fruit is of good quality and has a mild pleasant, sub-acid flavor. It ripens from the 2nd to the16th of July and hangs well to the tree until the first of September.

The tree is medium sized, round topped with horizontal branches and long pendant twigs, a very poor, short lived tree. The foliage is abundant, dark green and free from aphis and plant diseases. During the past five years it has produced one fair crop and four very large crops of fruit. One of the oldest and most popular sour cherries in cultivation. It is what is commonly known as the "Kentish" or "Pie" cherry. One of our most satisfactory sour cherries.

English Morello—Introduced from Europe. A medium sized, purple to black red, roundish, oblate fruit with a thick, short stem, small round stone, thin, tender skin and a meaty,

juicy, light red flesh. The fruit is of fair quality and of a rich acid to slightly astringent flavor, ripening from the 6th to the 20th of August.

Te tree is medium sized, spreading with slender branches and has dark green foliage which is free from aphis and plant diseases. During the past five years this variety has produced two fair crops and three heavy crops. One of the best of the Morello type.

Gibb—A large, dark crimson to purplish red, roundish heart-shaped fruit with a heavy stem, thick, tender skin, a large oblong stone, and dark red, meaty flesh. The fruit is of good quality; has a rich sub-acid flavor and ripens from the 25th of July to the 1st of August.

The tree is a medium sized, round headed, open topped tree with long, thick branches and slender pendant twigs. The foliage is medium sized, light green and not very abundant. During the past five years this variety has produced four light crops and one heavy crop of fruit. While an attractive large fruit and a good strong tree, yet it is not considered valuable from a commedcial point of view.

Heartshaped Weischel—Imported from Russia by Prof Budd in 1883. A small dark red to purple red, roundish, oblong fruit with short stem, round pointed stone, thin tender skin, and a dark colored, firm ,meaty flesh. The fruit is of a fair quality with a bitter, astringent flavor until dead ripe when it is fairly good. It ripens from the 1st to the 15th of July, but holds fruit in good condition until the first of September.

The tree is round topped and spreading with numerous slender pendant twigs and an abundance of beautiful dark green foliage making it a very attractive tree. It is a light yielder rarely producing a big crop. Not profitable.

Herformize Weischel—Same as Heartshaped Weischel.

June Morello—Introduced into the United States by Prof. Budd in 1883. A medium sized, bright red, roundish, oblate fruit with a heavy, short stem, thin skin, small lopsided stone and a yellow meaty flesh. The fruit is of fair quality and

has a rich sub-acid flavor, ripening from the 10th to the 20th of July and frequently hanging to the tree in good shape until the last of November.

The tree is vigorous, medium sized, has a dense, spreading top, straight, strong branches and numerous pendant twigs. The foliage is dark green, abundant and practically free from aphis and plant disease. During the past five years it has produced one good crop and four very light or almost failures. Its quality makes it desirable, but its yielding habits make it unprofitable.

Large Montmorency—Probably an American variety of the Montmorency family. A large, deep crimson, roundish oblate fruit with a short, thick stem, thin tender skin, small, round pointed pit and a yellow, juicy flesh. The fruit is of good quality; has a rich acid flavor and ripens from the 10th to the 20th of July. The fruit frequently hangs to the tree in good condition until the first of October.

The tree is tall, upright, round topped, having strong lateral branches and numerous pendant branches. The foliage is dark green, very abundant and free from common pests. During the past five years it has produced two good crops and three very heavy crops. It is a regular annual bearer, and very popular for commercial planting.

Late Duke—An old variety of European origin bearing large dark red, roundish, heartshaped fruit with a long stem, large round stone, thick, tender skin, and a firm, meaty, light yellow to stained flesh. The fruit is of good quality; has a mild, sub-acid flavor and ripens from the 1st to the 10th of August. The fruit frequently hangs to the tree until the middle of September.

The tree is a large, upright, open topped tree with strong horizontal branches and long, slender twigs. The crotches are wide and strong, rarely ever splitting under the heavy loads of fruit. The leaves are large, dark green, abundant, clean and free from all kinds of pests. It bears heavy annual crops which ripen slowly and come after other cherries have ripened. One of our best and most popular cherries for eastern Washington.

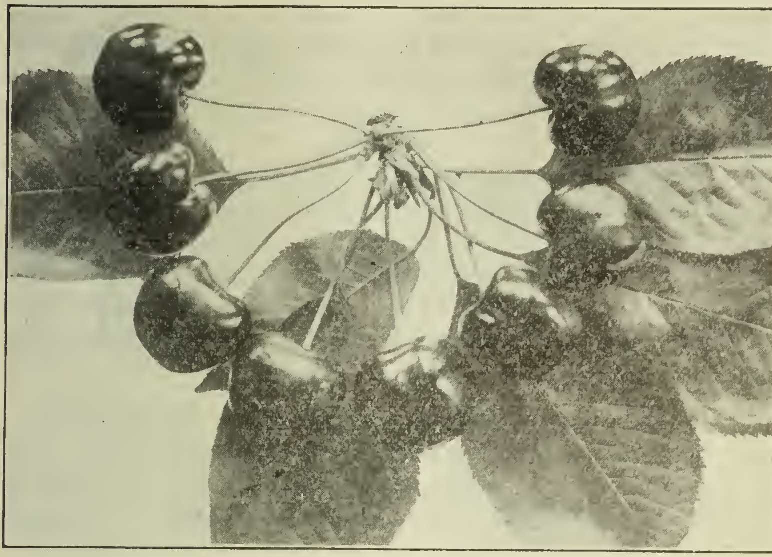

Fig. 5. Bing. One of Our Best Commercial Varieties. One-half Natural Size.

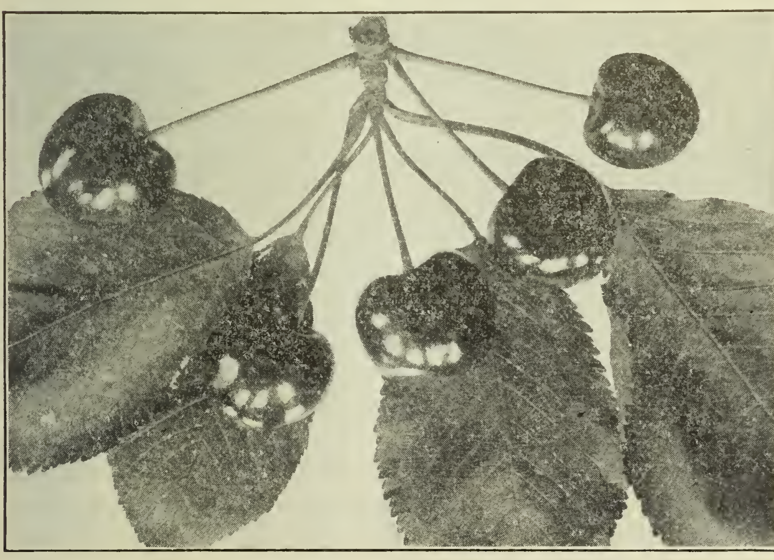

Fig. 6. Lambert. One of Our Best Commercial Varieties. One-half Natural Size.

May Duke—An old European variety of large size, dark red to purplish crimson, almost round to obtuse, heartshaped fruit with a long slender stem, medium sized, flat stone, thin, tender skin and a reddish purple, tender, melting flesh. The fruit has a very good quality, rich acid flavor and ripens from the 25th of June to the 10th of July.

The tree is a large, upright, open topped tree with long slender branches, narrow, strong crotches, slender twigs and an abundance of dark green foliage. During the past five years it has produced one light crop; two medium sized crops and two very heavy crops. This is one of our most satisfactory cherries being comparatively hardy, almost free from insect pests and a good thrifty grower.

Montmorency—An old European variety with large, light red, roundish, oblate fruit. It has a thick, short stem, thin tender skin, and a yellowish, juicy, meaty flesh. The quality is good and the flavor rich, vinous and pleasant. It ripens from July 10th to July 25th and the fruit frequently hangs on the tree until the first of October.

The tree is a round, drooping, spreading, low topped tree with horizontal, long, strong branches and slender, recumbent twigs. The leaves are small, abundant and dark green. A very attractive tree for ornamental planting. During the past five years it has produced three small crops; one medium sized crop and one very large one. It is not considered profitable for commercial cherry culture as the fruit is rather soft and of low quality.

Northwest—Originated by D. B. Weir, of Lacon, Ill. A medium to large, dark red to almost purple, roundish, heartshaped fruit with thick, tough skin, small round stone and a firm, deeply colored flesh. A cherry of excellent quality and a mild acid to slightly astringent flavor. One of our very best sour cherries. A heavy annual bearer, producing very satisfactory crops.

The tree is a medium sized, round topped tree with slender, recumbent branches and an abundance of dark green, healthy, clean foliage. This is one of our most common sour cherries, doing well under practically all conditions.

Olivet—A variety of French origin. A medium sized, clear dark red, round, heartshaped fruit, with a short heavy stem, a thick, but tender skin, round, medium sized stone and a tender, juicy flesh. The fruit is of excellent quality, rich, spicy flavor and ripens from the 1st to the 12th of July.

The tree is a small, round headed, open topped tree with short, thick, horizontal branches, long slender twigs and wide strong crotches. The foliage is dark green, abundant and entirely free from insect pests and plant diseases. During the past five years this variety has produced four large crops and one medium sized crop. This is by far our best sour cherry, considering the size of fruit, productiveness, quality and general habits of the tree.

Orel Sweet—Introduced from Russia. A medium sized, dark crimson to purplish, roundish, oblate fruit with a long slender stem, thick tender skin, round, small stone and a deeply stained, soft flesh. The fruit is of good quality and has a rich sub-acid flavor.

The tree is large, unright, with closed regular top, long slender, pendant branches and an abundance of dark green leaves. The fruit ripens from the 20th to the 30th of July. During the past five years this variety has produced two medium sized crops and three large crops of fruit. It is one of our best, medium sized but not sweet cherries.

Ostheim—Introduced by Prof. Budd from Russia in 1883. A medium sized, dark red, slightly heartshaped fruit with a short stem, small round stone, thin, tender skin and yellow, meaty flesh. The fruit is of good quality and has a mild acid flavor, ripening from the 10th to the 21st of July.

The tree is a large, upright, round topped tree with strong upright branches, long slender twigs, narrow but stout crotches and a fair amount of medium sized, light green leaves. During the past five years it has produced four light crops and one very large crop. While this variety has been largely planted, yet it is not considered profitable from a commercial standpoint.

Ostheim Weichsel—Of Russian origin. A large, dark crimson, roundish, heartshaped fruit with a rather long stem,

medium sized pointed stone, thin, but tough, skin and a firm, juicy flesh. The fruit is of fair quality, rich acid flavor and ripens from the 25th of July to the 5th of August.

The tree is a small, low, round headed tree with short, thick branches and slender, pendant twigs. The foliage is dark green and not very abundant. It is rarely ever attacked by insect pests or plant diseases. During the past five years this variety has produced one light crop, two medium sized crops and two big crops of fruit. It is not considered profitable for commercial planting.

Reine Hortense—An old European variety which has been sold under many names. A very large, bright red, roundish, elongated fruit, with a long, strong stem; large, long stone, thick, tender skin and light colored, firm juicy flesh. The fruit is of good quality and has a rich sweet flavor ripening from the 10th to the 18th of July.

The tree is a small, upright, concial shaped tree, with short strong branches and long slender, well leafed twigs. The foliage is a dark green, abundant and comparatively free from insect pests and plant diseases. During the past five years this variety has produced three small crops and two very large crops of fruit. On account of the softness of the fruit it is not considered profitable as a commercial cherry.

Skalanka—Introduced from Russia in 1883 by Prof. Budd. A medium sized, bright crimson, roundish, oblate fruit with a slender, short stem; small, round stone; thick, tough skin and a yellow, melting, juicy flesh. The fruit is of fair quality; has a rich acid flavor and ripens from the 1st to the 10th of July.

The tree is medium sized; has a spreading, round top long, pendulous twigs and wide, strong crotches. The foliage is light green and very sparse. During the past five years this variety has produced two fair crops and three very large crops of fruit. This is one of our promising cherries.

Wragg—Originated by J. Wragg, of Waukee, Iowa, as a sprout of an English Morello. A small, dark crimson, roundish, oblong fruit, with a rather short stem; long, blunt pointed stone; thin, tender skin and a slightly stained, meaty flesh. The fruit is of rather poor quality; prominently acid, and ripens from the 1st to the 10th of August.

The tree is a small, low, flat, round headed tree with long, thick, pendant branches; long twigs and an abundant of dark green leaves—a typical sour cherry form. During the past five years it has produced one fair crop and four very large crops of fruit. While not commonly grown this is one of our very promising sour cherries.

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HEARTS AND BIGARREAUS.

Bing—A seedling of the Black Republican, originating in 1875 in the nursery of Seth Lewelling, of Milwaukie, Oregon. A very large, purple black, obtuse, heartshaped fruit with a short, heavy stem, small oblong seed, thin, tough skin and dark purple red, meaty, juicy flesh. The fruit is of excellent quality and has a rich sweet, pleasant flavor. It ripens from June 15th to 25th, in the valleys, and from July 1st to 12th on the uplands and clings well to the tree even after it has become dead ripe.

The tree is a large, vigorous, erect grower with long, strong, horizontal branches and good wide crotches. The foliage is dark green and abundant but very subject to shot hole fungi. The Bing is one of our best trees in the orchard. During the past five years this variety has produced two light crops and three very heavy crops. It is undoubtedly our best sweet cherry for the uplands of eastern Washington and one of the best for the irrigated districts of the state. Its meaty flesh, tough skin and keeping habits makes it one of the best cherries grown on the coast for long distance shipping. In the irrigated sections of the state it is a regular bearer of large annual crops.

Black Republican—A seedling of the Black Eagle, originating in 1860 in the nursery of Seth Lewelling, of Milwaukie, Oregon. A medium to large, purple to black, roundish, heartshaped fruit with a short heavy stem, small round, smooth stone, thick, firm skin and dark red, firm, juicy, meaty flesh. The fruit is of high quality and a rich, spicy, pleasant sweet flavor. It ripens from the 15th to the 20th of June in the valleys and from the 8th to the 18th of July in the uplands.

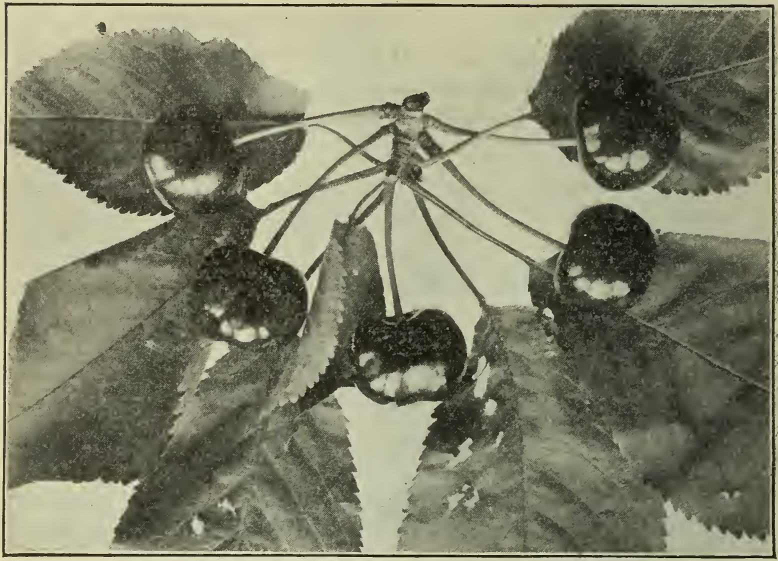

Fig. 7. Lewelling. A Popular Commercial Variety. One-half Natural Size.

Fig. 8. Royal Ann. Our Best Light Colored Cherry. One-half Natural Size.

The tree is a strong, vigorous grower, producing a beautiful pyramidal tree with strong, upright branches and numerous twigs. Its leaves are large, dark green and abundant but very subject to the shot hole fungi. This variety is very productive in the valleys and is very much liked as a commercial cherry, but it is not adapted to the conditions of the upland districts.

Black Tartarian—Of Russian origin. A medium to large purple almost black, obtusely heartshaped fruit with a long slender stem, rather large smooth stone, a thick tender skin, and a meaty, firm, deeply colored flesh. The fruit is of good quality, has a rich sweet, pleasant flavor and ships well. It ripens from July 10th to the 20th and hangs well to the tree.

The tree is a large, thrifty, upright grower with numerous strong, erect branches and crotches and abundance of dark green beautiful foliage which is free from diseases but annually severely attacked by the black aphis of the cherry. In the lower alititudes and western Washington it is very productive but the fruit buds are too frequently killed to be a profitable sort for the uplands of eastern Washington. During the past five years it has produced specimens four times and a light crop once. While a fruit of very high quality, it is not adapted for general planting.

California Advance—Originated by W. H. Chapman, of Napa, California. A medium to large yellowish red, heartshaped fruit with a rather long stem, large irregular stone, thick, rather tough skin, and a firm, light colored, juicy flesh. It has a rich sweet flavor and ripens from June 20th to July 1st.

The tree is an erect grower with strong branches, abundance of dark green leaves and is practically free from insect pests and plant diseases. During the past five years it has produced three very large and two fair crops.

Coe Transparent—Originated in Middletown, Connecticut. A medium sized, pale amber to light red, roundish oblong fruit with a rather long stem, large smooth stone, very thin tender skin and a light colored meaty flesh. The fruit is of good quality, mild subacid to sweet flavor, ripening from the 15th of June to the 1st of July on the uplands.

The tree is thrifty, large, tall, upright, open topped with strong horizontal to upright branches and an abundance of dark green beautiful foliage. While it is comparatively free from plant diseases, yet it is always seriously affected by the black aphis of the cherry. It ripens from a week to ten days earlier than any other cherry and is always seriously raided by the birds. It is valuable for this reason since they get a fill of this early fruit and do not molest the later sorts. During the past five years it has produced three light and two good crops of fruit. Its thin, very tender skin makes it undesirable for shipping purposes.

Elton—An old sweet cherry of European origin having a medium sized light yellow mottled with red and a round heart-shaped fruit. The stem is long and heavy; the stone small and round; the skin thick and almost white. It ripens from the 15th to the20th of June in the valleys and produces regular medium sized crops.

The tree is vigorous, large and upright with abundance of dark green foliage. Valuable for early use and close markets.

Galopin—Introduced from France. A medium to large, clear, bright red, round heartshaped fruit with a short, heavy stem, thin tender skin, large, flat, irregular shaped stone and a stringy almost meaty flesh. It is of fair quality; has a rich subacid flavor and ripens from the 15th to 25th of July.

The tree is a strong, upright grower with an abundance of dark green foliage practically free from orchard pests. During the past five years it has produced two very light crops; one fair crop and two very heavy crops. Not considered valuable for commercial planting.

Governor Wood—Originated in Cleveland, Ohio. A medium sized light yellow and bright red, oblong, heart shaped fruit with a very thin tender skin, large long stem and light yellow, soft juicy flesh. It is of good quality and has a rich sweet flavor. It ripens from June 10th to June 20th in the valleys.

The tree is vigorous, round headed and compact. Very productive in the valleys, but too tender for the uplands of eastern Washington. A good early fruit for close markets but too soft for long shipments.

Fig. 9. Vilne Sweet. Our Hardiest and Best Light Colored Variety for Uplands. One-half Natural Size.

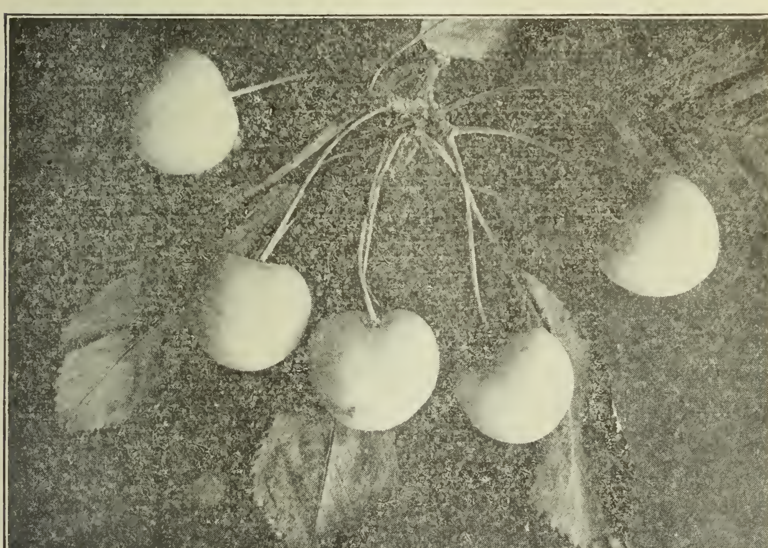

Fig. 10. Yellow Glass. A Popular Home Orchard Cherry. One-third Natural Size.

Graham—A small dark red, round fruit with slender stem, small round stone, thin tender skin and light red, juicy flesh. A cherry of good quality and rich sweet flavor. It ripens from the 20th to the 29th of July and is a regular annual bearer of fair to large crops.

The tree is medium sized, of upright growth and has an abundance of dark green, medium sized leaves. The fruit is rather small for commercial use.

Hoskins—Originated on the farm of C. E. Hoskins, of Newberg, Oregon. A large, roundish, heartshaped fruit with a medium length stem, large round stone, thin, rather tough, skin and a meaty, deeply stained, juicy flesh. The fruit is of good quality; has a rich sweet flavor and ripens from the 7th to the 15th of July.

The tree is a large, upright, spreading, open topped tree with strong crotches and an abundance of dark green foliage. During the past five years it has produced two light crops, two medium sized crops and one very large one.

Lambert—Originated on the farm of J. H. Lambert, of Milwaukie, Oregon, 1888. A large, dark red, heartshaped fruit with a rather heavy, short stem, large long stone, thick, tough skin and a dark colored, firm, meaty, juicy flesh. The Lambert is a fruit of excellent quality and has a rich, mild sub acid to sweet flavor. It ripens from the 10th to the 15th of June in the valleys and from the 16th to the 25th of July on the uplands.

The tree is a vigorous, upright grower with strong crotches and limbs and an abundance of dark green leaves which are usually seriously affected with the black aphis of the cherry. While it is not a heavy bearer on the uplands, yet it is a very satisfactory cherry. In the valleys it is one of the best sorts for commercial use. During the past five years it has produced three light crops and two very full crops. This is believed by many to be the best all round sweet cherry now in the west.

Lewelling—A seedling of the Black Tartarian, originating in 1872 in the nursery of Seth Lewelling of Milwaukie, Oregon, A very large, purplish black, heartshaped fruit with a thick,

tough skin, rather large oblong stone, a heavy short stem and a dark purple, firm, meaty flesh. It is of high quality and has a rich sweet flavor, ripening about the 20th of July, but remains in good condition on the tree for a month to six weeks.

The tree is a vigorous, upright grower with strong branches, wide crotches and an abundance of dark green foliage which is frequently attack by cherry aphis and shot hole fungi. While well adapted to the valley conditions, this variety is not adapted to the uplands. A light unsatisfactory yielder in our orchard.

Lincoln—Originated by Seth Lewelling, of Milwaukie, Oregon, in 1865. A medium sized, very dark red, round, hearshaped fruit with thick, tough skin, very short stem, small round stone and a firm, deep red, juicy flesh, ripening from the 20th of June to the 1st of July. It is of good quality and has a rich sweet flavor.

The tree has a large, spreading, open top with strong, erect branches and good crotches. Its foliage is dark green and abundant but seriously affected with the black aphis of the cherry. During the past five years it has failed to produce a single full crop and what does begin to color are usually taken by the birds before they are thoroughly ripe. Not productive in eastern Washington.

Major Francis—Originated by G. W. Walling, Oswego, Oregon, about 1865. A rather large, dark red, heartshaped fruit, deeply stained, juicy flesh. It has a good quality and a sweet rich flavor. The fruit ripens from the 25th to the 30th of June an is nearly always taken by the birds as soon as it colors.

The tree is a very large, upright grower with strong, erect branches and narrow, but strong crotches. The foliage is abundant, dark green, but is usually seriously attacked by the black aphis. During the past five years it has produced three light and two fair crops. While of good quality and attractive color, yet it is considered valuable only as a bait for birds in order to attract them from more valuable sorts.

Markirsche—A rather large, dark red, heart shaped fruit with a short stem, round smooth stone, thick tender skin and

a deeply stained meaty flesh. It is of excellent quality and has a very rich flavor. The fruit ripens from the 15th to the 23rd of July frequently clinging to the tree until the 10th of August.

The tree is a large, thrifty, upright, opentopped tree with strong crotches, numerous twigs and an abundance of dark green foliage which is frequently attack by the cherry aphis. During the past five years it has produced two fair crops and three big crops of fruit. Not commonly planted but considered by many to be a worthy fruit.

Ox-Heart—Of European origin. A medium sized, light red and yellow, long heartshaped fruit with thin tender skin, long narrow pointed stone, long slender stem and light yellow, solft melting flesh. The fruit ripens in the valleys from the 10th to the 15th of June and is fairly regular as a yielder of good crops.

The tree is a large, upright grower with strong branches and an abundance of dark green foliage. It is frequently attack by the black aphis of the cherry. While an excellent fruit for home or near by markets it is too soft for long shipments.

Plymouth Rock—A medium to large light red mottled, roundish oblong cherry with long slender stem, large long stone, thin tender skin and white, juicy, melting flesh. A fruit of good quality and rich sweet flavor. The fruit ripens from the 4th to the 10th of July.

The tree is an upright, round topped tree with strong branches and an abundance of dark green leaves. It is not a heavy annual bearer.

Rockport—Of European origin. A large, light red, to amber colored, round heartshaped fruit with short stem, thin tough skin, long, irregular stone and sweet flavor.

The tree is a large, regular, round headed tree with long slender, upright branches and horizontal twigs. The foliage is dark green and abundant but very seriously troubled with the black aphis of the cherry. During the past five years this variety has produced four light crops and one big crop. While a thrifty grower and a fruit of good quality yet it is not regular enough bearer to warrant general planting.

Royal Ann—(Napoleon) Of European origin. The old well known Napoleon of the east. A large light red and yellow, oblong heartshaped fruit with rather long stem, small oblong stone, thin, tough skin and yellow, firm, juicy flesh. A cherry of extra fine quality and rich sweet flavor, ripening from the 15th to the 20th of June in the valleys and about the 10th of July on the uplands.

The tree is a large, upright grower with long branches, strong crotches and a large number of fruiting twigs. The foliage is abundant, dark green, but seriously troubled with the black aphis of the cherry. Our best and most successful light colored sweet cherry for the valleys but too tender in wood and bud for the uplands. It is a regular annual bearer.

Vilne Sweet—Im ported from Vilne in the southwest Russia by Prof. Budd. A large, dark red, oblong fruit with long slender stem, large oblong stone, thin, tender skin and yellow, rather firm, meaty flesh. A comparatively little known cherry of good quality and a rich sweet flavor, ripening from the 10th to the 16th of July and hanging to the tree in good shape until the last of August.

The tree is a medium sized, irregular, upright grower with long strong branches and numerous slender twigs. Its foliage is dark green, abundant, and practically free from insect pests and plant diseases. During the past five years this variety has produced one light crop, two fair crops and two very heavy crops. It probably is the hardiest sweet cherry grown here at the station and while not as firm as similar varieties, yet it gives promise of being an excellent sweet cherry for the uplands of eastern Washington.

Wagner—A medium to large, dark red, roundish oblate fruit with rather short, heavy stem, almost round stone, thin tender skin and a yellow, meaty, melting flesh. A cherry of good quality and rich subacid to almost sweet flavor, ripening from the 10th to the 16th of July.

The tree is an upright, round topped tree with long upright branches and short thick twigs. Its foliage is dark, plentiful and practically free from plant diseases and insect pests. During the past five years this variety has had one failure, two fair crops and two heavy crops.

Yam—Originated in California. Rather large, purplish red, roundish, heartshaped, attractive fruit with a heavy long stem, large round stone, thick tough skin and deeply stained, firm, juicy flesh. The fruit is of excellent quality and has a rich sweet pleasant flavor, ripening from the 1st to the 15th of July.

The tree is a medium sized, upright, pyramidal shaped tree with long strong branches, very narrow crotches and an abundance of dark green leaves which are usually seriously attacked by the black cherry aphis. During the past five years this variety has produced one medium sized crop and four almost failures. While the fruit is rather nice the buds are too tender to withstand our winters.

Yellow Glass—Introduced from Russia by Prof. Budd. A medium to large, light lemon colored, roundish, heartshaped fruit with a long stem, round large stone, thin but tough skin and a firm, yellow, meaty flesh. The fruit is of fair quality; has a mild subacid to sweet flavor and ripens from the 20th to the 27th of July.

The tree is a large, upright, strong grower with abundance of large, light green leaves. During the past five years this variety has produced one light crop and four very heavy crops. This is one of our most attractive cherries, but not considered of commercial importance on account of its color. It is very pleasant to eat out of the hand and while not as sweet as some cherries yet it is a very nice variety for the home orchard.

STATE COLLEGE OF WASHINGTON
AGRICULTURAL EXPERIMENT STATION
PULLMAN, WASHINGTON

INVESTIGATIONS CONDUCTED AT

WESTERN WASHINGTON EXPERIMENT STATION

PUYALLUP, WASHINGTON

I. A Preliminary Report on Some Experiments in Clearing Logged-off Land with a Stump Burner

II. A Promising Method for Destroying Stumps and Logs

By W. H. LAWRENCE

Bulletin No. 93

1910

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PART I.

A PRELIMINARY REPORT ON SOME EXPERIMENTS IN CLEARING LOGGED-OFF LAND WITH A STUMP BURNER.

By W. H. LAWRENCE.

INTRODUCTION.

A more rapid development of the agricultural lands in and near the timber area in Washington is desirable, since, in many cases, the demand for farm produce exceeds the supply. This condition can be overcome in case a more rapid and less expensive method in clearing logged-off land can be practiced. Generally the present methods as practiced have proven to be too slow and ineffective, or too expensive to be practiced by one of limited means. Cheaper and more serviceable methods are desired. Usually the more rapidly the method and the greater the results, the higher the cost per acre. Owing to so great a demand for money in other industries which are paying good dividends on short investments, only a limited amount of capital has been available for use in clearing land or in making more rapid and effective the present methods. More recently, however, the clearing of logged-off land is receiving much more attention. Much time is being devoted to a more careful study of the older methods, with the hope of improving them. Also, time is being devoted to devising and trying newer methods.

SERVICEABILITY OF METHODS OF LAND CLEARING.

The oldest method is the hand method. By the use of peavies, mattocks, shovels and axes, the dirt is removed from the roots, which are then cut off and piled around the stump with the remainder of the debris and burned. An immense amount of slow and extremely taxing labor is required, but the land when cleared is in a better condition than when cleared by other methods. More recently capstans and stump-pullers have been used to a good advantage, in connection with the hand method. The work is made less laborious and more rapid, but the cost is usually somewhat greater. The work of removing stumps has also been facilitated and made more effective, under a wide range of conditions, by the use of stumping powder. In removing stumps by this method, large holes are made in the ground which must be filled before plowing can be done. The subsoil is scattered over the surface soil and the pieces of the stump must be gathered together and burned. The cost of the powder, the work of filling the hole, collecting, piling and burning the debris makes the method an expensive one. Boring intersecting holes into the base of the stumps and burning them (also practiced in burning down large trees) has also been a serviceable method. While the destruction of logs by boring and burning has proven more successful, yet it requires as much time and hard labor, as does the practice of boring holes in stumps and burning them. In the case of the latter, however, very frequently the crown fails to burn, thus leaving the large roots intact. To complete the destruction by burning is oftentimes tedious and quite difficult work. In using stumping powder, which is the last resort in such a case, the explosion of powder usually breaks the weaker portions of the crown and fails to remove the roots. It is then necessary to place several smaller blasts in order to accomplish the desired results. In many cases it is necessary to separate the roots by hand in order to handle them to a good advantage. The charcoaling or pitting method is proving to be a very satisfactory and effective but slow method of destroying stumps. This method, like

a majority of the others, does not provide for complete land clearing. All of the down trees and small timber not burned with the slashing must be destroyed. The use of stumping powder for splitting and loosening stumps preparatory to pulling and piling them with a donkey engine has proven to be the most rapid method. This method, as practiced by many, has proven to be a very expensive one. After the stumps have been pulled and piled with the logs and other debris collected and piled by the aid of the donkey engine, it is necessary to remove many roots which were broken off when the stumps were pulled, after which the large hole in the ground must be filled before the land is ready for the plow. While the method is a good one, it is expensive and requires considerable ready money. The use of the various types of stump-burning machines has been made with largely varying success, depending upon the condition of soil (variety of soil and water content) and the kind and condition of the timber. The above mentioned methods variously modified have been the most effective ones followed in land clearing.

OBJECT OF THE EXPERIMENT.

While some methods have been more serviceable than others, none have yet met the requirements of the land owner of very limited means who possesses a few acres of logged-off land which was originally purchased for a home.

An inexpensive but serviceable machine by which logs and stumps can be destroyed very rapidly and at a low cost, and with very little injury to the soil, easy to operate, requiring the attention of one or two persons, will to a large degree meet the requirements of the homemaker. With these requirements in mind, the stump-burner described below was given a limited trial with sufficient promising results to warrant publishing the information gained in using the same.

THE STUMP-BURNER USED IN THE EXPERIMENTS.

The stump-burner consists of a 1½ horse-power gasoline engine with 13-inch flywheel and adjusted to run 650 revolu-

tions per minute; a circular fan (No. IV American blower with $8\frac{1}{2}$-inch fan and $2\frac{1}{2}$-inch pulley) provided with a patent wind distributor tapped to attach five lines of $1\frac{1}{2}$-inch hose; hose couplings; pieces of $1\frac{1}{2}$-inch rubber hose of different lengths; a number of pieces of galvanized iron tubing; a few small iron plates, and several lengths of boiler tubing slightly curved at one end, which are used as blow-pipes. The hose couplings are used to attach the rubber hose to the wind distributor and the blow-pipes. The tubing, which is of the right diameter to fit inside of the hose tightly, is connected with short pieces of rubber hose 18 to 24 inches in length. By using tubing and short pieces of hose of variable lengths the right size to telescope, provision is made for varying the length of line of hose as desired. The lines of hose are very light and easily adjusted, since no couplings are required. The tubing connected by short pieces of hose also prevents doubling, thus retarding or stopping the current of air. From the description, it is plainly seen that the stump-burner is small, light in weight and very cheaply constructed. At a later date the blower was coupled with a two-horse-power gasoline engine and mounted on a truck. With the latter engine a few trials in operating a wood-boring auger by power were made as described on another page of this bulletin.

THE PLAN OF WORK.

The machine was set in a convenient position to burn several stumps at a time. Auger holes, two inches in diameter, were made in the base of the stumps. The boring was done by hand. The auger was directed inward and downward in order to extend the hole as low and as far as the center or even three-fourths to seven-eighths of the diameter when the stumps were of large size. Short pieces of hose with couplings on one end were attached to the wind distributor, and sections of galvanized iron tubing inserted, after which alternate sections of hose and tubing were added in order to make the lines of hose of sufficient length, after adding the last section of hose with the blow-pipe attached, to reach the stumps. A fire was then

started in each auger hole by using live coals of wood or kindling. The machine was set in motion in order to fan the fires. In burning, it was the plan to drive the fire to the center of the stump and to confine it as long a time as possible, preventing, if possible, the forming of a large opening at the point of entrance. This was accomplished by inserting the blow-pipe into the opening as fast as the burning would allow. Occasionally, burning around the blow-pipe takes place more rapidly than desired. In such a case it was found advantageous to use an iron plate of sufficient diameter to cover the hole. The plate has an opening in the center large enough for the insertion of the blow-pipe. By keeping the fire confined it is less difficult to drive it into the main roots than when allowed to burn in the open. The blow-pipes must be moved frequently in order to keep the fire burning briskly and to the best advantage. When the fire is confined and the air is constantly forced into the small space, the heat becomes so intense that the air burns as it leaves the blow-pipe, forming a long flame. The heat generated under such conditions is intense. Small rocks were readily melted when placed in the stumps which were burning briskly. The intense heat produces charcoal very rapidly. The layer of charcoal apparently retards the rate of burning. It was found advantageous under some conditions to frequently remove the layers of charcoal, using a long-handled iron chisel. After the center of the stump has been partially burned out and the opening is large enough to permit the introduction of kindling, it is an excellent plan to insert as much small wood as possible. The bed of coals formed by the kindling aids to maintain an intense heat. Excellent use of the debris can be made in burning the roots after the crown of the stump has been largely destroyed. From a very limited trial, it is evident that charcoaling and pitting the roots may be practiced to a good advantage at this stage in the use of the stump-burner. Burning large logs is also quite readily accomplished. The best results were obtained by boring a hole as near the underside of the log as possible and about three-fourths through it, after which the fire was controlled as described above. Small debris (sections

of dead limbs, etc.) may be inserted into the log to a good advantage after the fire has made a cavity of some size. Again, as in burning stumps, it is advisable to remove the charcoal by using the long-handled chisel.

After the logs have been burned into sections and reduced in weight so that they can be handled to a good advantage, the tops of the stumps (which are seldom entirely burned) may be piled with the other debris, consisting of all small stuff, together with the small trees which have been cut into sections for convenience in handling, and burned. It is advisable to use the outfit only in case marked results cannot be obtained in burning the pile.

KIND AND CONDITION OF LOGS AND STUMPS BURNED.

Trials were made in burning both cedar and fir under various conditions. The first trials were made in a marsh, in burning cedar stumps and logs which were so saturated with water that it was impossible to burn them without the aid of a machine. The intense heat, generated by the burning air and wood (especially when the fire was confined), produced a heat which dried the wood faster than burning took place. This trial lasted for a period of eight days. The results obtained under such conditions were encouraging. Better success, however, was met with in burning fir.

Stumps of various ages and conditions were burned. It is found that the greater the stump, the more quickly it could be destroyed. The condition of the older stumps was found to vary from solid to badly decomposed, by the action of the elements, assisted by saprophatic fungi and wood-boring ants. Stumps consisting of fir wood which have not absorbed very much water are easily burned. Naturally the more pitch they contained the more rapidly combustion took place. Those stumps, however, in various stages of decay and full of fungi, and in many cases well saturated with water, were usually more difficult of destruction. Concerning the various conditions of fir stumps, it can be said that the general appearance is no indication of the

ease with which they may be burned. In several instances, stumps apparently sound, as indicated by external appearance, were so thoroughly saturated with water throughout the greater portion of the heart wood that, after the holes were bored, the water continued to drip or even in some cases to run from the wood for a period of several minutes and even hours. The intense heat which can be generated by the aid of such a machine is sufficient to destroy the most water-soaked and decayed forms, although the progress is much less rapid under such conditions.

THE EFFECT OF BURNING THE SOIL.

One of the most important considerations connected with clearing the land is the burning of the soil. An examination of an area of land before the slashing is burned reveals considerable leaf mould and humus on the surface and in the surface soil. Following the fire, no humus is found on the surface and little or none in the soil, since a very large proportion, if not the entire amount, has been destroyed during the burning. The burning of the slashing is necessary, and the injury done the soil cannot be controlled. In using the stump-burner it has been observed in this experiment that the soil is burned but very little. This is due to the fact that the blow-pipes can be placed so that the fire is directed to the best advantage. It has also been observed that in case the soil is dry, the volume injured is greater than where moisture is abundant. The water evidently prevents the heat from penetrating more than a few inches. It may also be said concerning this method of burning that the damaged soil is not left on the surface, but, since it forms a part of the subsoil, is buried when the hole formed by the destruction of the stump has been filled. It is also true that the virgin soil which has been exposed to the elements for so long a time is not burned or mixed with the subsoil, as such is the case in leveling after clearing when stumping powder has been used in connection with various devices, such as teams and tackle, donkey engine and stump-puller. It is also to be noted that the volume of soil damaged by burning in this method of clearing is but a small area as compared with the diameter of the stump de-

stroyed. It is the opinion of the writer that of the various methods of land clearing which injure the soil, this one does the least of any of the methods practiced.

Inquiry has been made concerning the fertilized value of ashes of wood which has been burned in this manner. The volume of ash is small. There is very little potash present, since the high temperature to which most of the ash has been exposed volatilizes the compound containing this essential plant food.

THE DETAIL OF EXPERIMENTS.

The first test with the outfit was made in a marsh in burning cedar. Trials were made to destroy logs and stumps in all sorts of conditions—some solid, consisting of perfectly sound wood, while others were in various stages of decay, many times consisting of mere shells filled with rotten, water-soaked wood. A very large proportion of this material was thoroughly water-soaked. While very slow progress could be made in burning the partially dry logs, etc., by the usual method, nothing was accomplished in burning the stumps or piles of water-soaked logs, unless the machine was used. By the aid of the blower, however, burning was accomplished at a reasonable cost. The conclusion drawn was based upon the expense of operating the machine, as compared with the amount of work accomplished.

The second test was made in burning fir stumps which had been split by the use of stumping powder. It was easily demonstrated that splitting the stumps previous to burning with such a machine makes the work tedious and much more expensive. The fire is much more difficult to control, since it is impossible to produce a great enough heat to do as rapid burning as under conditions where burning is easily controlled.

During the third test a fir log cut in 1907, eighty-five feet long, with an average diameter of thirty-six inches, partially sound and partially infested with fungus, and which had split about one-third its length when cut down, was burned in ten hours' time—five lines of hose, nine hours, and one line, five hours. The log was burned in sections which were rolled to-

gether by the aid of a peavy, and the burning finished by the use of one line of hose.

Two green fir stumps, one five feet in diameter five feet above the ground, twenty-two feet around the base at the ground, with twelve large roots, and the other four and a half feet in diameter six feet from the base and measuring a little under nineteen feet around the base, with eight roots, were burned off in a twelve hours' run. The twenty roots, with the exception of three very large ones, were burned below the level so that the plow would go over them. A run of four hours with four lines of hose was required to finish the work. The cost to do the work, basing the cost of labor at 30 cents per hour, and a charge of 70 cents for gasoline and oil, the average price for removing the stump would be $2.60 each.

Twenty-two hours' work on a green fir stump about five feet in diameter, with large spreading roots, gave less encouraging results. The small fir burned out completely, even the smaller roots penetrating to a depth of three feet. The crown of the cedar burned, separating the roots but not low enough for plow to pass over them. The roots of the large fir were water-soaked, hence burning was almost impossible. In both cases, the crowns were burned out, separating the roots. Basing cost on above mentioned price, the average cost was $2.73.

The sixth test was made on cedar stumps, one two and a half feet, and one four feet in diameter, and a green fir five feet in diameter six feet from the base. It took twenty-eight hours to complete the work. The roots were not burned out. During this test a delay of several hours was caused by a disabled engine, thus making it impossible to control the fire to the best advantage. The cost per stump was $2.93 in this trial.

A group of five old fir stumps, one two feet, two each three feet, and two each two feet and six inches in diameter, each nine feet high, more or less decayed and thoroughly soaked with water, were burned, low enough to destroy the crowns, thus separating the roots, in a twenty-two hour run. These stumps were in such a water-soaked and decayed condition that the fire would not burn after the blowers were removed. The roots could

not be burned, owing to the abundance of water in the soil. The average cost for doing this work was $1.56 each.

Another group of five fir stumps, nine feet tall, with an average diameter of three feet six inches, mostly sound but water-soaked, were burned, as low as the soil conditions would permit, in twenty-seven hours. Again the crowns were destroyed, leaving the roots separate. The average cost of this work was $1.70 per stump.

Five large fir stumps, each ten feet in height, averaging five feet two and one-half inches three feet from the bases, were burned off so that all the crowns were destroyed, leaving the roots separate, many of which were also largely burned up. Forty hours' time was required to do the work. The cost of burning done on each of these stumps was $2.80.

CONCLUSIONS.

1. The economical destruction of large stumps is the most perplexing problem in land clearing. By the use of the the stump-burner the crowns of stumps are readily destroyed, thus leaving the roots separated. The roots may be burned below the surface so they will not interfere in cultivation, or they may be removed by the use of small quantities of stumping powder or some other convenient method—the method to be determined by the cost. The stumps of the smaller growth may be removed at this time and by the same method. The large logs may be burned in sections, the smaller ones cut into convenient length for handling, and the entire mass of debris, including the small rubbish, collected in piles and burned. By this method, the important problem of putting the entire mass into a condition so that it may be handled and burned quite readily is accomplished, leaving the land ready for the plow.

2. To operate the outfit described for a period of ten hours requires the services of one man, two gallons of gasoline, and a small quantity of cylinder oil. The cost for labor, at $2.00 per day, and two gallons of gasoline and a small quantity of cylinder oil would not make the cost of operating exceed $2.50 per day. In operating a five-line burner, the operator has time

to get together the small refuse, and to saw into convenient lengths for handling the timber which is too small to burn to a good advantage with the aid of the machine.

It is believed from the experience gained in the use of this stump-burner that one large enough and equipped to operate ten lines of hose at a time could be operated to a better advantage. The increase in cost of operation of a large machine would only exceed the original cost of operation of the five-line type by a small per cent. The large machine would require more gasoline and cylinder oil.

3. The average cost of burning stumps was $2.30. These stumps averaged 47 inches in diameter. To remove such a stump by blasting would require about 33 sticks (25 pounds) of powder at 13 cents per pound. The powder would cost $3.25. Considering the additional cost of doing the blasting, filling the hole caused by the explosion and the work required to destroy the stump after it has been removed by the use of powder, the practice of burning can readily be seen to be by far the cheaper one. It is also to be noted that the purchase of the powder requires $3.25 ready money. In using a stump-burner, the cost is represented very largely by labor at $2.00 per day.

4. Clearing land with a stump-burner requires good management in order to obtain good results. It is essential to place the blow-pipes in the right position in order to direct the burning to the best advantage and the right distance from the fire to insure rapid burning. The operator must be a good observer, industrious, and a steady worker to get the desired results.

PLATE I. Fig. A—A general view of a tract of land once heavily timbered but from which the logs were removed during the early days of logging. The secondary growth on the tract has since been cut down and has just been burned over.

Fig. B—A view of the same tract, showing the stumps of second-growth timber and the material which did not burn during the period of burning.

Fig. C—A view of several large stumps in various stages of decay, as shown by the irregular and much splintered tops. These stumps were thoroughly water-soaked, but were burned as low as soil conditions would permit, at an average cost of $1.70 per stump.

Fig. D—A general view of a small area once heavily timbered with cedar.

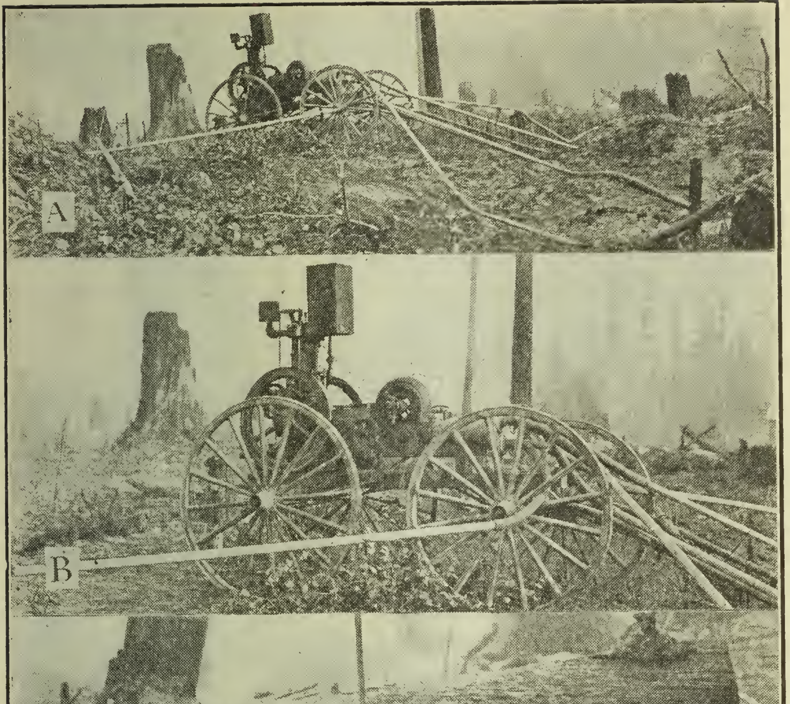

PLATE II. Fig. A—A view of the stump burner outfit mounted on a truck, showing the machine with the lines of hose attached.

Fig. B—A closer view of the machine, as shown in Fig. A.

Fig. C—The same burning outfit as seen when mounted on a skid.

Fig. D—Figure of the stump burner, as shown in Fig. C., which gives a better view of the machine, particularly of the wind distributor, and the attachment of the five lines of hose used to convey the air to the place of burning.

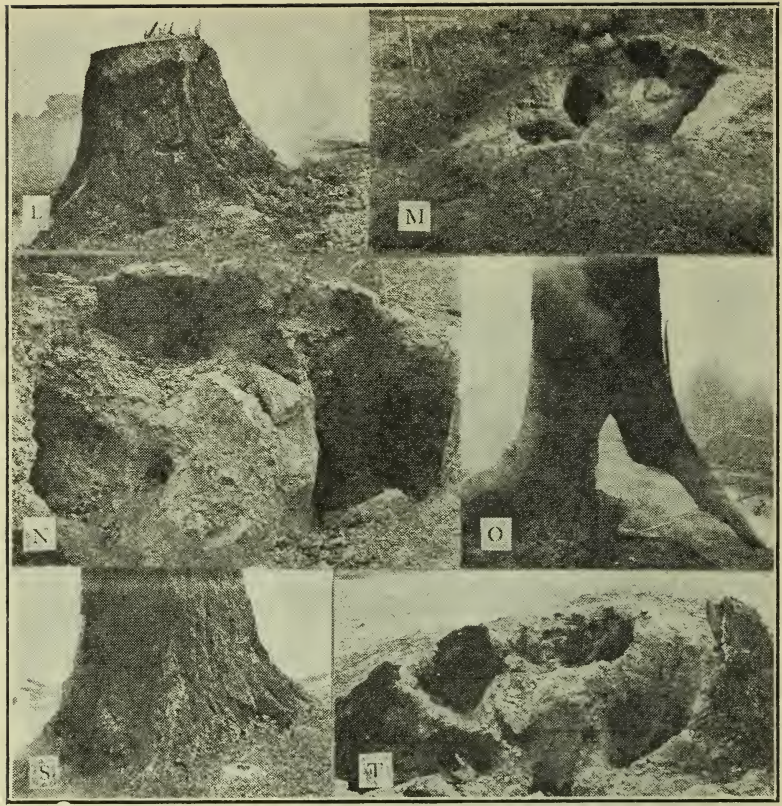

PLATE III. Fig. L—A green fir stump 5 feet in diameter at the top, measuring 22 feet around the base at the ground, with twelve large roots. This stump was burned out at a cost of $2.60. The roots, with the exception of three very large ones, were burned below the level, so that the plow would pass over them.

Fig. M—This figure shows the hole in the ground left when a small fir tree was burned by the aid of the stump burner. The entire tree was burned out, even the smaller roots, to a depth of three feet.

Fig. N—Fig. N is a view of the hole left in the ground after the stump shown in Fig. L was destroyed.

Fig. O—This figure shows the way in which the base of the stump is burned out in using the stump burner. A blow-pipe is placed so that the fire is driven into the roots, thus burning the crown of the stump and the greater portion of the roots near the surface of the soil.

Fig. S—The stump shown in this figure was 4½ feet in diameter six feet from the base, at which place it measured a little less than 19 feet in circumference. There were eight large roots. The crown of the stump was burned out in a twelve-hour run. The cost of burning this stump was $2.60.

Fig. T—Figure T shows the holes left in the ground after the large stump shown in Figure S had been destroyed, with the exception of three large roots, which spread out over the surface of the ground for a distance of several feet. This figure well illustrates the value of such a machine as used in the experiments in destroying the crown of a stump. Destroying the stump in this manner eliminates the problem of handling enormous weights of wood. The roots are all separated, thus making it easy to remove them by the most expedient and less expensive method for doing such work. It is sometimes advantageous to bore holes into the large roots and burn them below the plow line. In other cases, it is advisable to remove them in some other manner.

PART II.

A PROMISING METHOD FOR DESTROYING STUMPS AND LOGS.

By W. H. LAWRENCE.

As concluded in the first part of this bulletin, a stump-burner to be had at a reasonable cost, light in weight, and easy to handle, easily and cheaply operated, with which effective and rapid destruction of logs and stumps is accomplished, more nearly meets the requirements of the small land owner of limited means.

While the plan followed, to confine the fire and direct the current of air so that the greater portion of the interior of the log or stump has been consumed before the fire breaks out, has proven to be a successful and cheap method, a more rapid burning is desirable. It is also true that a stump or log, when properly bored so that the holes extend about three-fourths through the obstacle of destruction and they intersect, merging at a wide angle and are so slanted that a good draft is possible when a fire is started at the point of intersection, will in many cases be partially consumed, a log will usually burn into sections and the greater portion of the crown of a stump will be destroyed, yet leaving the large roots still united.

A judicious combining of these two methods appeared plausible. It was very evident from experience and observation with both methods that the slow and tedious work of boring the holes by hand is responsible for a large portion of the time consumed. It was also evident that in some cases at least much more effective and rapid work could be done by increasing the number of holes, in order to place the fires in different portions of the same piece of wood at the same time.

In order to accomplish the boring of a large number of holes, and at a rapid rate, some form of mechanical power must be

employed. The engine, mounted on the truck with the blower (also mentioned in the first part of this bulletin and shown in Plate I, Figs. 1 and 2) was fitted with a sheave wheel. A flexible shaft about 7 feet in length, provided with attachments to be driven by an endless rope, was fitted with a 1½-inch ship auger with a special shank about 18 inches in length. The flexible shaft was then fastened to the stump or log to be bored by using a chain. It was then set in motion by the endless rope, guided by pulleys attached by leads to the nearest and most convenient obstacle, running on the sheave wheel of the engine. Running at a rate which did not make the task of holding the auger a difficult one, holes 15 to 18 inches in depth were easily bored in twenty to twenty-eight seconds. The average was twenty-five seconds. Using the same auger, and running it at the same speed, holes were bored to a depth of thirty to thirty-two inches in fifty seconds to one minute in time. The average was fifty-five seconds. The more rapid rate at which holes were bored to a depth of from fifteen to eighteen inches was due to the structure of the auger. The speed of the auger was sufficient to run shavings clear of the hole until it was inserted past the worm. Occasionally pitch seams or small knots cause the worm to clog. After insertion past the worm, however, the shavings would accumulate in the hole at the top of the shank and at frequent intervals were removed by withdrawing the auger, causing the worm to force the shavings out.

In order to remove the shavings while boring at this rate, it is apparently necessary to equip the auger with a much longer worm. In the limited number of trials made, it was somewhat surprising to note that such rapid work could be done with very little delay on account of heating the auger. Care must be exercised at all times, however, so that the auger will not be heated enough to injure the temper.

To combine the method of burning by keeping the fire enclosed and briskly burning by use of the blower, and where the fire is given a natural draft as in the plan where intersecting holes are bored, a large fir log about 3½ feet in diameter was bored at four intervals about 6 feet apart. The plan in boring

was to make one hole straight into the lower side of the log about four inches from the lower edge and three-fourths the distance through it. Three to five holes were then made by directing the auger downward from the upper surface, connecting with the cross hole, if possible.

The fires were started in the lower holes, the blower set in motion and the results noted. The fire, constantly fanned in the lower holes, advanced into the vertical ones very rapidly. In some cases all the vertical holes had not been made to connect with the horizontal ones. In these cases the rate of burning at first was greatly retarded until the fire ate its way through the solid portions of wood, connecting the vents. The fire when fanned by the blower is driven into all the openings, and very shortly every portion is lined with fire, which is also driven in short columns several inches in length from the mouths of the openings. In the twilight, the several short and straight but even columns of fire, appearing like so many fiery spines growing from the log, each merging into a small column of smoke of various shades and colors, the several rings located at various intervals on the log, the glare and low constant roar of the fire, the hum of the fan, the explosion of the engine and the deepening of the evening shades as twilight merges into dusk, makes the scene of burning a weird and picturesque one.

Although several minor trials were made with good results, the main experiment was conducted on a large log. Each set of boring gave slightly different results. In one case the lower hole was bored entirely through the tree. It was impossible to burn to advantage, since a draft could not be produced in the longer and vertical holes. In another trial, the holes were not bored as deeply as the cross holes. It took some time to get the fire burning briskly and to connect all these vents with the lower one, since several inches of solid wood had to be consumed before a draft was possible. One trial, however, where the cross holes met with the vertical vents, in every case, the fire started in the lower hole, advanced into all the upper ones very rapidly, and continued to burn briskly. In less than one hour the entire center of the log had been burned out, leaving a shell about six

to eight inches in thickness. By making vents to direct the fire, burning can be easily controlled and made more effective by placing pieces of bark or sods of dirt over one or any number of the vents, thus stopping the drafts, and making a few new vents, if necessary.

The trials were very limited in developing this method, since they were necessarily discontinued by a disabled engine and followed by heavy rains interfering, and furthermore requiring the attention of the entire station force to care for grain and other crops.

Owing to a slight unavoidable change in the plan of the work, the writer finds it impossible to continue the work on this method at the present time. Believing that the results obtained are worthy of further consideration, the plan of work and conclusions drawn, together with the method pursued, is herewith given.

CONCLUSION.

This method is a very promising one, since—

1. The machine used is easy to handle and serviceable.

2. Much time is gained by boring the holes by power and makes it possible to bore large numbers of holes in a very short period of time.

3. Directing the flame by making vents insures burning in the desired direction. By the use of these vents, fire may not only be driven in the desired direction, but the rate of burning may be regulated. The rate of burning may be easily regulated by placing pieces of bark or sods over the vents or by inserting the section of the limb of a tree—using the thing at hand and procured with the least exertion.

4. Wood burns more rapidly when given a draft than where the fire is confined. The rate of burning may be regulated by the amount of air forced through the vents by the use of a blower.

5. Much effective burning may be accomplished by boring a series of holes for vents, after which the fires may be started and allowed to burn by the natural drafts—burning trees into sections and the tops of large stumps, etc.

6. Combining the methods of burning stumps and logs by the use of a stump burner and boring intersecting holes and burning, so that the fire is guided to the best advantage and caused to burn briskly by a continual forced draft is both practicable and advisable.

The State College of Washington
AGRICULTURAL EXPERIMENT STATION

PULLMAN, WASHINGTON

DEPARTMENT OF HORTICULTURE

POTATO INVESTIGATIONS

By A. G. CRAIG

BULLETIN No. 94
1910

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INTRODUCTION.

The peculiar climate and soil conditions of Washington are especially favorable for the production of potatoes. In many large sections the atmosphere is so dry during the growing period that it furnishes unfavorable conditions for the development of fungus diseases on the foliage, nor have we in this state the Colorado beetle (potato bug), which is so destructive east of the Rocky Mountains and annually necessitates the expenditure of large sums of money for spraying.

There is little danger of overstocking the potato market here. The eastern demand for Washington-grown potatoes is good and in the past has rarely allowed the price to fall below ten dollars per ton in car lots. In addition to this there is a rapidly increasing market for our potatoes in Alaska and at home. There are, however, few crops now grown in Washington which show greater variation in yield per acre than the potato. This crop responds to good culture to a greater degree than most others, and the grower who exercises proper care with his potatoes is always paid in yield and quality.

There are thousands of acres of land now devoted to summer-fallow which might produce good crops of potatoes with very little additional expense and yet leave the soil in better condition for wheat than it is under the present methods of summer-fallowing. The average cost of producing potatoes in eastern Washington is a little less than five dollars per ton. The plowing and harrowing which would have to be done on the summer-fallow land if potatoes were not grown is included in the cost. Therefore, potatoes grown in the place of summer fallow can be sold for a very low price and still leave a good balance. If the market remains as high as it has been for many years a net profit of fifteen to twenty dollars per acre from what would otherwise be idle land can easily be secured.

This bulletin is a report of an extended investigation of the possibilities of profitable potato culture in Washington. The experiments were as follows:

1. **Variety Tests.**—Over 225 varieties were grown under as uniform conditions as possible. In taking notes special at-

tention was paid to the yield, shape, and color of the tubers; whether adapted to summer or winter market, long or short seasons.

2. **Seed Selection.**—Experiments were carried out to dedermine the importance and practicibility of selecting the seed in the field. Tubers from individual hills were planted and the offspring were carefully studied. This was done through three generations and is to be continued. This experimental study was started for three purposes, (a) to find a means of determining the best plants before digging, (b) to determine the individual hereditary tendencies, and (c) to determine the accumulative effect of selecting year after year.

3. **Best Time to Plant.**—One variety was planted at different times from the second week in April until the 10th of June. Notes were also taken on plantings made by farmers.

4. **Amount of seed per acre under different conditions.**

5. **Best distances apart for hills under different conditions.**

6. **Number of Cultivations per Season.**—One plot was cultivated at intervals of once a week or ten days during the growing season and on a second plot cultivations were given after each rain only, to maintain a dust mulch.

7. **Destroying Weeds,** especially wild oats, with the harrow to diminish the hoeing and reduce the number of row cultivations.

8. **Mulching Versus Cultivation.**

The results of observations of field practices are not given in this bulletin except in the summary. The results of our experiments and studies of methods of farm practices in commercial potato growing have been briefly described in our Popular Bulletin No. 11.

VARIETY TESTS.

A large number of varieties were tested in 1905, 1906, 1907 and 1908. A full description and behavior of the plants of all varieties and their yields would be extremely lengthy, and because of that fact only a few are briefly described and placed in groups. In each group the varieties are placed in the order of preference—yield, shape, color, character of eyes, etc., being taken into consideration. The name of each variety is followed by the initials of the person or firm from which the seed was obtained. The addresses corresponding to these initials may be found in the list on page 17.

Group 1.—Varieties that produce new potatoes early and mature early in the season.

New Queen. (Y. & H.)—Marketable in seventy-five days. Plants large, vigorous, moderately spreading. Tubers large; form oval flattened, regular; skin, smooth light pink; eyes medium in size, uniform character, a little depressed and a little brighter pink than the skin. A very good variety for early market and promising for short season.

Peck's Early (F. & P.)—Marketable seventy-eight days. size, variable; form round to oval slightly flattened, irregular; Plants medium to large, vigorous, spreading. Tubers medium in skin smooth, light pink; eyes few, medium size, well distri buted, shallow, variable in character, not conspicuous. A few tubers have streaks of pink in the flesh. A very desirable early variety.

Pride of the South. (H. A. D).—This variety is known by several different names. (See synonyms page 14). This strain has given better results than the others. Plants medium in size with light green, large leaves. Tubers medium to small; form round, regular; skin finely netted, brownish to white with a few small blotches; eyes small, bright pink; flesh clear white. A handsome tuber.

Iris Cobbler. (V S.)—Marketable in eighty days. Plants medium size, vigorous, spreading. Tubers medium to small,

uniform in size and shape; form round very little flattened; skin a little rough, clear white; eyes small, inconspicuous. A good short season variety.

Early Ohio. (L. L.)—Marketable in eighty days. Plants medium size, light green color. Tubers average small; form oval slightly flattened, regular; skin smooth, light brownish pink; eyes medium number, rather small, shallow. A very good quality potato. Good strains of this variety give good yields.

White Ohio. (V. S. S.)—Marketable in seventy-five days. Plants medium to large, moderately spreading. Tubers medium in size, a little variable; form oval, slightly flattened, not always uniform; skin smooth, clear white; eyes variable in character, medium in size, light pink.

Six Weeks. (L. L. O.)—Marketable in eighty-four days. Plants edium size, spreading. Tubers medium to small; form round and oval, slightly flattened, fairly regular; skin smooth with a few netted spots at one end, brownish pink; eyes, medium in size, shallow but somewhat variable in character. A few tubers have pink streaks in the flesh.

New Early Standard. (H. A. D.)—Marketable in eighty-two days. Plants medium, vigorous, healthy, moderately spreading. Tubers medium in size, uniform; form round slightly flattened, regular; skin smooth, clear white; eyes medium in size, shallow and uniform in character. A very desirable early maturing variety.

King of Michigan. (V. S. S.)—Marketable tubers in eighty days. Plants medium to large, spreading. Tubers medium; form round to oval flattened, regular; skin coarsely netted, white; eyes small, shallow, inconspicuous. Good for short season.

King of the Earliest. (F. S. C.)—This variety resembles the Early Ohio in many respects. Flesh white with pink streaks.

New Century. (K. S. C.)—Marketable in eighty days. Plants medium size, moderately spreading. Tubers medium

size, uniform; form round, regular; skin smooth, light pink; eyes medium in size. Flesh clear white. Resembles the Ohio. A good variety for short season.

White Star. (H. A. D.)—Marketable in eighty-two adys. Plants medium in size. Tubers small; form oval flattened, a little irregular; skin smooth, clear white; eyes medium to small, shallow; flesh clear white. Requires good soil and plenty of moisture.

Early Thoroughbred. (F. & P. & H. B.)—Tubers marketable in eighty-five days. Ripened early in August, 1906, but the tops remained green until the middle of September in 1907. Plants medium sized and vigorous. Tubers resemble the Early Rose, but they are not so long as the Rose. The skin is netted, light pink; eyes medium to large and sunken. Occasionally a tuber has pink streaks through the flesh. Quality good.

New Climax. (F. & P.)—Marketable in eighty days. Plants small to medium. Tubers small, uniform; form round, slightly flattened, regular; skin smooth, clear white; eyes small inconspicuous. If the tubers were larger this would be almost an ideal early maturing variety.

Early Rose. (Department).—This variety has given variable yields on the Station grounds. A few farmers have reported good results with it. Marketable in eighty-five days. Plants medium size, vigorous. Tubers large, elongated flattened, regular; skin smooth, light pink; eyes vary in size and appearance. Flesh stained with pink.

Group 2. Varieties that produce new potatoes early and mature in early September.

Sweet Home. (F. & P.)—Marketable in eighty-four days. Plants large, vigorous, spreading. Tubers, large, very uniform in size and shape; form regular, oval flattened; skin very finely netted, clear white; eyes few, uniform, small, shallow; flesh clear white. A very promising variety for main crop, in semi-arid sections.

Champion of the World. (H. B.)—A very desirable early variety. Marketable in eighty days. Plants large, spreading. Tubers medium to large; form oblong, flattened, regular; skin smooth, creamy white; eyes variable in size and depth. Tubers small in 1908.

Early Excelsior. (Y. and H.)—Marketable tubers in eighty-four days. Plants medium to large. Tubers medium to large; form oval flattened, regular; skin netted, pinkish yellow; eyes, few, variable, medium to small, shallow, pink. A good summer variety for light soil.

Rural Red. (K S. C.)—Marketable in eighty-four days. Plants large vigorous, spreading. Tubers large, uniform; form oblong, flattened, irregular; skin smooth, brownish pink; eyes medium to small, shallow, compound, variable; flesh white slightly tinged with pink. Quality is good but the pink in the flesh is objectionable.

Crine's Lightning. (L. L. O.)—Marketable tubers in eighty days. Plants twelve to fifteen inches tall, vigorous, spreading. Tubers large; form elongated oblong, flattened, slightly irregular; skin netted, pink striped with different shades of pink; eyes variable in depth. Not desirable for market, but it is a good quality potato for home use.

White Victor. (L. L. O.)—Marketable in eighty-seven days. Plants medium size. Tubers medium to large, uniform; form oval slightly flattened, regular; skin netted, dull white; eyes uniform, medium to small, shallow; flesh white. Good looking tubers. A good yielding variety under favorable conditions.

Early Hamilton. (N. K. & C.)—Marketable tubers in eighty-three days. Plants vary from small to very large. Tubers medium in size; shape round, variable; skin slightly netted, yellowish white; eyes vary from medium to large, shallow inconspicuous. Good quality.

White Rose. (K. S. C.)—Marketable in seventy-eight days. Plants medium in size, moderately spreading. Tubers fairly uniform, medium to large; form elongated, flattened, regular;

skin smooth, white; eyes variable in character, but most of the tubers have medium sized, shallow eyes. Flesh clear white.

Group 3. Varieties that produce new potatoes early but mature late.

Burpee's Extra Early. (H. B.)—Marketable tubers in eighty days, but the plants did not ripen until the early part of October. Plants fourteen to eighteen inches tall, vigorous, moderately spreading. Tubers large and a little variable in size; form elongated ablong, flattened, fairly regular; skin smooth but a few are coarsely netted, mottled with white and pinkish yellow; eyes medium number, well distributed, quite shallow but variable in shape and depth.

Arcadia. (F. S. C.)—Marketable tubers in eighty-seven days, but the plants did not mature until the middle of October. Plants medium size. Tubers large, somewhat variable; form oblong, flattened, fairly regular; skin smooth, clear white; eyes few, small, shallow.

Bovee. (H. B.)—Marketable tubers in seventy-eight to eighty-two days. Plants eighteen to twenty inches tall, vigorous, moderately spreading. Tubers medium to large, inclined to be variable; form elongated oblong, slightly flattened, not regular; skin netted at the seed end, white, with a slight tinge of pink; eyes quite variable in size and depth. Not extra for market.

Early Jewel. (H. B.)—Is subject to second growth.

Algoma. (L. L. M. C C.)—Marketable tubers in seventy-eight days. The tubers are inclined to be variable in size and shape.

Crown Jewel. (J. & S.)—Marketable in eighty-four days Ripe in October. Plants medium in size. Tubers large, uniform; form oval flattened, regular; skin smooth, white; eyes large, doop.

Group 4. Varieties that produce good marketable potatoes and ripen early in the fall. Promising for "Palouse Country" and some parts of the "Big Bend."

American Wonder. (H. B.). —Plants large, vigorous, with many branches. Tubers large, uniform; form elongated oblong, quite regular; skin smooth, clear white; eyes medium in number and size, shallow; flesh creamy white. A good early maturing main crop potato.

White Lily (Carl Engle, Coupeville, Wash)—This variety is grown very extensively on Whidby Island. The tubers resemble the Burbank but the plants mature earlier. Plants large, foliage light groon. Tubers uniform, large; form elongated oval, somewhat flattened, regular; skin finely netted, clear white; eyes medium number, well distributed, medium to small, shallow, inconspicuous.

Carman No. 1 (H. B.)—A very desirable, fairly early maturing main crop potato, especially for light soils. Plants medium in size. Tubers medium to large, fairly uniform; form oval flattened, regular; skin a little russeted, white; eyes few, well distributed, small, shallow; flesh clear white.

Pink Eyed Seedling. (C. B. B.) (Tested one year.)—Plants medium in size, spreading. Tuber medium size, very regular and uniform; form oval flattened; skin netted, white; eyes few well distributed, inconspicuous; flesh white. The tubers appear well.

Green Mountain. (Y. & H.)— A few farmers in Eastern Washington report favorable results with this variety. In 1907 the tops were all dead the 5th of October. Plants large. Tubers large; form round and oblong slightly flattened, a little irregular and variable; skin a little coarsely netted, white; eyes medium in number, well distributed, medium size and somewhat variable in character. Very good in quality.

New Burbank. (J. A. S.)—For our climate and soil conditions this variety is superior to the Burbank. Plants are a little smaller than the Burbank plants but otherwise they appear the same. Tubers medium to large, uniform; form elongated oblong, regular; skin smooth, a few fairly netted, clear white; eyes medium in number, well distributed, shallow and uniform in character. Matures latter part of September.

Netted Gem. (L. L. M. & C.).—Plants medium to large, uneven. Tubers large; form elongated, spindle; skin rough, yellowish, with russet netting; eyes medium number, well distributed, inconspicuous; flesh white. A fair yielding, good for home use and banking purpose.

Sir Walter Raleigh. (V. S. S.)—A very good variety of the Rural type. It matures fairly early and is less liable to become hollow than the Rural New Yorker. Plants medium sized. Tubers uniform, large; form flattened oblong to round, regular; skin finely netted, clear white; eyes few, well distributed, medium size, shallow, inconspicuous.

Vermont Gold Coin. (W. A. B.)—This is avery promising main crop potato. Although it gives a large yield it does not require a very long season to mature. Plants very large, vigorous. Tubers uniformly large; form oval and slightly flattened oblong, regular; skin finely netted, yellowish white; eyes few, well distributed, medium size, shallow.

Washington Wonder. (C. B. B.) (Tested one year).—Plants medium to large, compact, dark green foliage. Tubers medium size; form oval flattened; skin smooth, white; eyes few, small, inconspicuous; flesh white. The tubers present a good appearance and a fair yield was obtained.

Group 5. Heavy yielding varieties that mature late in the season. Require a long season, good soil and a large amount of moisture.

New Late White Nebraska. (V. S. S.)—Plants medium to large, dark green. Tubers medium size; form oval flattened; skin smooth, white; eyes few, well distributed, shallow, inconspicuous; flesh white. A handsome potato.

Burbank. (H. B.)—At present the Burbank is grown in the state more than any other variety. In a few sections it is all that could be desired for late variety, especially on light soil, but it does not give good satisfaction in other sections. It frequently does not mature well and it has a strong tendency to make a second growth, (produce knobby tubers). Some strains of the variety are better than others.

Plants large to very large. Tubers large; form elonogated, flattened, not always regular; skin smooth, clear white; eyes medium in number, well distributed, medium size, somewhat variable in character.

Governor Folk. (J. A. S.)—A heavy yielding potato, but it requires a very long season. Plants large, vigorous, spreading. Tubers large, fairly uniform size; form round, flattened slightly elonogated; skin finely netted white; eyes few, well distributed, vearying from small to large, but most of them are shallow.

Peerless. (J. W.) (Tested one year).—Plants large, spreading, dark green foliage. Tubers medium size; form oblong flattened; skin finely netted, white; eyes variable, some deep but most of them are shallow; flesh white.

Ross Favorite. (H. B.)—A good market variety, but it requires a long season. It resembles the Rural New Yorker No. 2. Plants variable in size, vigorous, moderately spreading. Tubers uniformly large; form variable, short, oval; skin finely netted, dull white; eyes few, well distributed, shallow, but a little variable in character.

Rural New Yorker No. 2. (N., K. & C. and H. B.)—One of the best-known late varieties. It is remarkable for its smooth, white, short flattened, oblong tubers. It has a tendency to grow too large and hollow in some sections of the State, on rich soil, when the hills are too far apart or not enough seed is used per acre. It requires a long season.

Snowflake Jr. (C. B. C.)—Plants large, vigorous. Tubers medium to large, uniform; flattened round, very regular; skin finely netted, clear white; eyes few, well distributed, medium size, shallow. A handsome tuber. Requires a long season.

Snowflake Jr. (C. B. C.)—Plants large, vigorous. Tubers medium to large, uniform; form flattened round, very regular; skin finely netted, clear white; eyes few, well distributed, medium size, shallow. A handsome tuber. Requires a long season.

Carman No. 3. (N, K. & C.)—This is a good variety on account of its size, shape, color and shallow eyes. The Rural

type. Plants medium in size. Tubers uniformly large; form round to oblong, flattened, regular; skin finely netted. clear white; eyes few, well distributed, medium size, shallow.

White Beauty. (P. S. B. G.)—A very promising variety, but it requires a long season. Plants medium size. Tubers large; form flattened round, quite regular; skin smooth, clear white; eyes few, well distributed, medium size, shallow, inconspicuous.

White Mammoth. (F. & P.)—It resembles the Rural New Yorker, but does not have the tendency to grow too large or become hollow. Plants medium to large. Tubers very uniform, large; form slightly flattened oval, regular; skin smooth, clear white; eyes few, well distributed, small, shallow; flesh clear white.

North Pole Easterly. (H. B.)—Plants very large, vigorous, moderately spreading. Tubers large; form slightly flattened long, but variable; skin finely netted, clear white; eyes very variable in character, but a large number of them are medium in size and shallow.

Harvest King. (F & P.)—Requires long season. Plants small to medium, spreading. Tubers large, uniform; form slightly flattened round to oblong, fairly regular; skin finely netted, white; eyes few, well distributed, medium to small, shallow but; somewhat variable in character.

Great Divide.—(W. A. B. & H. B.)—Plants large. Tubers uniformly large; form elongated oblong, but not flattened, regular; skin finely netted, clear white; eyes many, well distributed, medium size, shallow but a little variable in character.

North Pole Stinnett. (H. B.)—Plants large, spreading. Tubers large; form much elongated, irregular; skin finely netted, yellowish white; eyes few, well distributed, medium size, moderately deep. Some second growth.

Group 6. Heavy yielding varieties, undesirable for market purposes, but advantageously grown for stock feed. A few are good for market purposes in unfavorable seasons.

Johnson's Seedling. **(H. B.)**—Plants very large. Tubers very large, variable in size and shape; skin pink, rough; eyes large, prominent. Subject to second growth.

Purple and Gold. **(H.B.)**—There are two kinds of tubers in this variety and neither strain is desirable for market purposes, but they give heavy yields.

Pingree. **(N, G. & C.)** —This is a very prolific variety, but the tubers vary too much in size and shape to be desirable for market purposes. Plants very large. Tubers large, irregular; form flattened oval to oblong; skin finely netted, clear white; eyes few, shallow and variable in character. Gave good results in 1908.

Red Jacket. **(K. S. C.)**—Not good for market purposes on account of the very large irregular, rough pink tubers with red tinged flesh.

Empress of India. **(H. B.)**—A good yielding potato but it is not desirable for market on account of its light purple skin.

Synonyms, some of which are described above.

Bliss Triumph (H. A. D.), Bliss Red Triumph (W. H. M.), and**Red River Early Triumph (L. L. O.),** are from all appearances exactly the same variety. Too small to be of much value.

Early Ohio (L. L. O.), Extra Early Ohio (N., K. C.), Improved Early Ohio (V. S. S.), Ohio Junior (P. S. B.), Red River Acme (L. L. O.), and **Red River Early Ohio (L. L. O.),** are from all outward appearances of the plants and tubers the same. **Early Triumph (J.H.C.), Harleinger (H. B.),** and **White Star (H. A. D.),** resemble the above varieties in many respects.

Early Rose (Hort. Dept. and H. B.), Prolific Rose (F. & C.), are much alike.

Early White Triumph (I. S. C.), Norton Beauty (J. M. T. & Co.), Pride of the South (H. A. D.), Quick Lunch (Uncle Gideon) (W. A. B.), and **White Triumph (V. S. S.),** are from all appearances the same variety. **Junior Pride (H. B.),** is the same as the above in all characteristics, with one exception. The sprouts on the latter are tinged with pink and the sprouts on the former are not colored.

Red River White Ohio (L. L. O.) and **White Ohio (F. S. C. and V. S. S.)** are exactly the same.

The tubers of **Rose of the North (I. S. C.)** are a little lighter colored than are **Seedling of Early Rose (H. B.)**, but otherwise the plants and tubers are exactly the same.

Discarded Varieties—Not Worthy of Description.

Asparagus, (H. B.).

Banner (P. S. B. G.), Bartlett, (P. S. B. G.), Bliss Triumph (H. A. D.), Bliss Red Triumph (W. H. M.), Blue Victor, (H. B.,) Bonanza (A. A. R. S. C.), Breed's Seedling (C. B. B.), Burbanks' Seedling, (H. A. D.).

Champion (H. B.), Chnoays (H. B.), Clinton (L. L. O.), Columbian (P. S. B. G.), Commercial (L. L. O.), Considerable Seed (P. S. B. G.).

Delaware (K. S. C.).

Earliest (J. A. S.), Early Andes (P. S. B. G.), Early Market (L. L. O.), Early May (O. E. A. B.), Early Michigan (K. S. C.), Early Minnesota Rose (F.S. C.), Early Northerner (H. B.), Early Pinkeye (F. & P.), Early Pioneer (P. S. B. G.), Early Puritan (H. B.), Early Regent (H. B.), Early Snowball (F. & P.), Early Triumph (J. H. C.), Early Vermont (H. B.), Early White Harvest (J. A. S.), Early White Triumph (I. S. C.), Early Wisconsin (J. A. S.), Empire State (O. A. E. B.), Extra Early Eureka (L. L. O.).

Freeman (W. H. M. and H. B.).

Garnechills (J. W.), Garnet Chily (H. B.), Good Time (J. A. S.), Goroachi (Japan), Gov. LaFollette (J. A. S.).

Harleinger (H. B.), New's Early (V. S. S.) , Hundred Fold (H. B.).

Ionia Seeding (L. L. O.), Irish Belle (O. A. E. B.).

Junior Pride (H. B.), Junior Pride of the South (H. B.).

Kennewick (H. B.), Kokhaida (Japan).

Late Rose (J. W.), Leopard (C. B. B.), Lincoln (P. S. B. G.), Long Red Horn (H. B.), Livingston (O. A. E. B.).

Maggie Murphy (H. B.), Main Crop No. 2 (P. S. B. G.), Mann's Enormous (V. S. S.), Martin's Horn (H. B.), Medium (P. S. B. G.), Milwaukee (C. B. C.), Mountain Prizetaker (L. L. O.).

Ohio Junior (P. S. B. G.), Okame (Japane).

Pat's Choice (L. L. O.), Pearl of Cannon Valley (F. S. C.),

Nort Beauty (J. M. T. & C.), North Pole (H. B.).

Planet (O. A. E. B.), Potentate (F. & P.), President McKinley (P. S. B. G.), Prosperity (K. S. C.), Prolific Rose (F. & C.), Pure Gold (P. S. B. G.), Phoebus (Central Russian and U. S. Dept. Agrl.)

Quick Lunch (Uncle Gideon) (W. A. B.).

Red River Acme (L. L. O.), Red River Early Triumph (L. L. O.), Reliance (H. B.), Rose of the North (I. S. C.), Rust Proof Hullets (P. S. B. G.).

Scab Proof (J. A. S.), Seedling of Early Rose (H. B.), State of Maine (H. A. D.), Silver Coin (C. B. B.), Snohomish (C. B. B.), Suck's Dwarf (Hort. Dept), Sunlight (J. A. S.), Emperor (W. A. B.), Supreme (H. B.).

Tannenyophen (H. B.), Temple (H. B.).

Up-to-Date (P. S. B. G.), Uncle Sam (P. H.).

Vignosa (J. A. S.), Viol (Central Russia and U. S. Dept. Agrl.), Violet Mommoth (F. S. C.), Vornehm (L. L. O.).

Washington F. & P.), Washington Early (S. P. F.), Waltmann (Central Russia and U. S. Dept. Agrl.), White Elephant (H. B.), White Triumph (V. S. S.), Wilson's First Choice (H. B.), Windsor Castle (H. B.), Wonderful (P. S. B. G.).

SEED FIRMS.

A list of the initials and corresponding names and addresses of seed firms and individuals who furnished seed for these variety tests.

O. A. E. B.—Baldwin, O. A. E., Brigham, Michigan.

H. A. B. S. Co.—Berry, H. A. Seed Co., Clarinda, Pa.

C. B. B.—Breed, C. B., Bothell, Wash.

W. A. B.—Burpee, W. Atlee & Co., Philadelphia, Pa.
H. B.—Benthien, Henry, Fife, Pierce Co., Wash.
C. B. Co.—Currie Bros. Co., Milwaukee. Wi.s
H. A. D.—Dreer, H. A., Philadelphia, Pa.
C. E.—Engle, Carl, Coupeville, Wash.
F. S. Co.—Farmer Seed Co., Faribault, Minn.
R. J. F. & Co.—Farquhar, R. & J. & Co., Boston, Mass.
F. & P.—Flansburgh & Pierson, Leslie, Michigan.
S. B. G.—Green, Prof. S. B., Minneapolis, Minn.
J. H. Co.—Harris, Joseph, Co., Coldwater, N. Y.
P. H. & Co.—Henderson, Peter & Co., New York City. N. Y.
I. S. Co.—Iowa Seed Co., Des Moines, Iowa.
J. & S.—Johnson & Stokes, Philadelphia, Pa.
K. S. Co.—Kansas Seed Co., Kansas City, Mo.
W. H. M.—Meuls, Wm. Henry, Philadelphia, Pa.
L. L. M. & Co.—May, L. L. & Co., St. Paul, Minn.
N. K. & Co.—Northrup, King & Co., Minneapolis, Minn.
L. L. O.—Olds, L. I., Madison, Wis.
J. A. S.—Salzer, John A., La Crosse, Wis.
J. W.—Wood, James, Bristol, Wash.
V. S. S.—Vaughn's Seed Store, Chicago, Ill.
U. S. D. A.—U. S. Dept. of Agruculture, Washington, D. C.
Y. & H.—Young & Halsted, Troy, N. Y.

SEED SELECTION.

Introduction.

Farmers do not think of selecting the poor animals for sires and dams, nor do they plant their unmarketable grain; but many plant potatoes which are of no value except for stock feed. The question is asked, ''Why do varieties run out?'' There are almost as many theories advanced and remedies given for this running out as there are growers. A few of the remedies given are : ''Plant when the moon is bright' "''Always plant large tubers'': ''Never plant 'seeds ends': ''Always leave one or two eyes to a piece'': ''Exchange seed, etc.'' None of the above remedies will prevent the varieties from running out. Varieties run out when the seed is not proprly selected from year to year. The place to select seed is in the field.

If the variety is a good one to start with, any farmer with the proper knowledge can maintain its productiveness and quality with comparatively little time and expense, and the careful farmer can increase its productiveness and improve its quality. There are few plants under cultivation that are more susceptible to variation than the potato. The more a plant varies the greater is the chance for improvement with proper methods of selection, as is also the corresponding tendency to deteriorate when poor methods are practiced. As we dig potatoes or look at them in the bin, we cannot but note the remarkable lack of similarity, or the tendency to variation, that is exhibited. It is a noticeable fact that some hills will have a large number of tubers, uniform in size and shape, while other hills grown under the same conditions will have a few ill-shaped tubers or one large tuber and a few small ones. (See cut). A tuber from a vigorous, productive plant, though small because it started late and did not have time to develop full size, would possess and transmit the characteristics of its worthy parent. So also the only large tuber from the poor hill, in which it alone attained marketable size, would

Fig. 1. Variety—White Mammoth.

Tubers—Pile to the right selected hills. Pile to the left, medium to poor hills.

inherit the tendencies of its parent. We see then that inspection of the individual tuber alone will not enable us to judge whether or not it inherits desirable characteristics. So the farmer when selecting from the bin or pit can tell nothing about the parentage of the large or small potatoes. If he

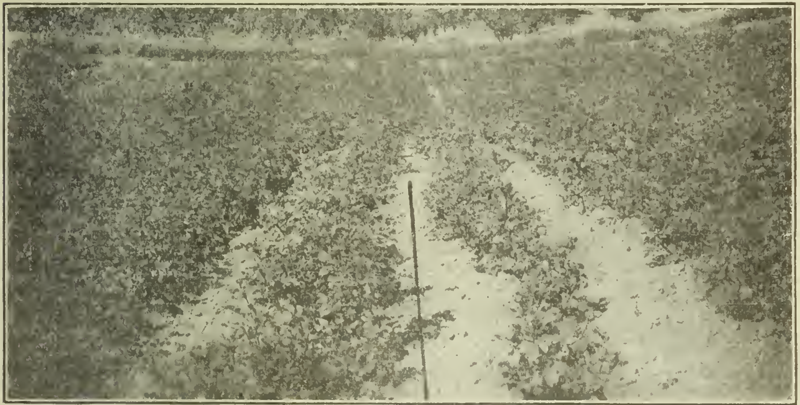

Fig. 2. Variety—White Mammoth.

Plants.

Two rows to the left of line from selected hills. Two rows to right of line from medium to poor hills.

selects all large tubers from the bin the large potatoes from the poor hills will be selected, as well as those from good hills, and the small tubers with good hereditary tendencies, will be rejected. (See Fig. 2). To know the hereditary tendencies, we must know the characteristics of the hill and the vigor of the plant. The whole plant, then, and not the single tuber, must be taken as the unit for selection. The place to do this is in the field, where the whole plant can be examined.

Farmers frequently ask, Which is best for seed, large or small potatoes? The small tubers from the good hills can be taken without any ill results, provided they are not smaller than the cut pieces. When the time for field selection is passed and the potatoes for seed must be taken from the bin or pit, it is best to select the medium sized tubers.

Seed Selection Experiments.

To study the inherited tendencies in hills, two or more hills of several varieties were selected in 1906 and the tubers from each hill were planted separately in 1907. The following Table I. gives weight of tubers in selected hills, a short statement of condition of tubers, yield per acre, and a short statement of condition of crop in 1907. The habits of the plants were also studied quite carefully.

The selection experiments teach that the heaviest yieldind hills are not always the best for seed, and that to select hills for seed intelligently the number of plants in a hill must be taken into consideration. This was done when the hills were selected for the 1908 crop.

In 1908 two plots each of twelve varieties of potatoes were planted. One plot of each variety was planted with seed selected from the best hills. Large and small tubers of the hills were planted. The other plot was planted with seed selected from the medium to poor hills. A large percent of the tubers from the medium to poor hills would usually be taken by the farmer if the tubers were taken from the bin for seed. As near as was possible, the two plots of each variety had the same kind of soil and treatment. The results are given in the following Table II.

Table 1—Results of the selection of individual hills. The most productive hills are not always the best hills.

	Variety	Lbs. Tubers	Hills selected in 1906	Mark'ble Bushels	Small Bushels	Results in 1907
1	Carman No. 3	6	Tubers uniform in size and shape	202.8	38.2	Fair to good.
2	Carman No. 3	3 1-2	Tubers uneven in size, fair shape	172.8	86.5	Tubers inferior to No. 1.
1	Sweet Home	3	Tubers irregular in size and shape	363.0	45.4	Fair, uniform. Not as good as No 2
2	Sweet Home	1	Tubers uniform in size and shape	589.1	60.5	Fair, uniform.
1	Garnet Chily	10 14-16	Tubers all medium sized, uniform shape	125.3	43.2	Fair, irregular.
2	Garnet Chily	4 1-2	Tubers irregular in size	17.9	34.2	Small, irregular
1	Garnet Chily	6 5-16	Tubers fair size and shape	215.1	53.8	
2	Garnet Chily	2 14-16	Tubers all small	165.0	49.5	
1	Maggie Murphy	8 1-2	Tubers both large and small	235.7	54.5	Irregular in size and shape.
2	Maggie Murphy	3 1-2	Tubers both large and small	275.0	44.4	Not as good as No. 1.
1	Medium	6 1-2	Tubers fair size and shape	257.1	28.8	Fair to good.
2	Medium	1 1-2	Tubers fair size and shape	114.9	78.7	Fair to good.
1	White Star	13 3-4	Tubers very irregular in size and shape	152.0	10.4	Very irregular in size and shape.
2	White Star	10 1-4	Tubers fairly uniform in size and shape	349.1	63.5	More uniform than No. 1.
3	White Star	2 1-2	One large ill-shaped tuber, one medium, and five small ones	108.0	47.6	All small and uneven in size.
1	Netted Gem	6 1-2	Tubers quite uniform in size and shipe	354.9	52.4	Some hills not as good as others.
2	Netted Gem	2	Tubers not even in size	267.5	82.2	A great difference in hills.
1	Ross Favorite	7 1-2	One very large tuber, rest variable	178.5	42.3	More difference in hills than No 1.
2	Ross Favorite	5 14-16	A few good tubers, the balance irregular in size	219.6	67.2	Hills quite variable.
3	Ross Favorite	10 1-4	Tubers regular in size	220.9	60.5	Difference in hills tubers irregular
1	Pure Gold	8 1-4	One very large tuber, the rest small	73.6	68.7	All small.
2	Pure Gold	7 1-2	Some good tubers, a few small	156.1	50.7	Better tubers than No. 1.
3	Pure Gold	4 1-2	Tubers fair	118.2	66.0	Tubers fair.
1	Pat's Choice	5 1-2	Tubers below medium size	115.3	62.4	All rather small.
2	Pat's Choice	3 1-2	One very large tuber, rest small	137.5	60.5	From very large to very small
1	Snowflake Jr.	6 3-4		381.6	76.5	A little small but good.
2	Snowflake Jr.	4 1-2		408.4	81.8	A little small but good.
1	Tanneyophen	4		218.8	44.2	Tubers fair.
2	Tanneyophen	1 1-3		194.4	69.2	Great difference in hill and tubers.
1	Beauty of Hebron	Large	Tubers medium size, a few small	338.8	66.5	Very good.
2	Beauty of Hebron	Medium	Tubers large and small	605.0	40.3	Exceptionally good.
1	Champion of World	Large	Tubers even in size	299.6	51.8	Tubers uneven in size.
2	Champion of World	Medium	Tubers even in size	400.0	19.0	Tubers fairly uniform.
1	Early Puritan	Large	Tubers not even in size, a few small	345.7	47.5	Hills variable, tubers irregular.
2	Early Puritan	Medium	Not as many tubers as in No. 1, but more uniform	199.6	66.5	Hills uniform, tubers fair.

TABLE II

First Years' Selection and Results.

No.	Variety	Tubers Selected	Product from good hills: Lbs per acre Marketable	Product from good hills: Lbs per acre Unmark'ble	Product from poor hills: Lbs per acre Marketable	Product from poor hills: Lbs per acre Unmark'ble
1	Carman No. 1	9 good hills—48 lbs.	8003	1558	....	....
2	Carman No. 1	16 med. to poor hills—60 lbs.	....	....	7277	1695
1	Carman No. 3	9 good hills—46 lbs.	10039	1788	....	....
2	Carman No. 3	32 med. to poor hills—54 lbs.	....	....	7968	2478
1	Dewey	10 good hills—57 lbs.	12855	2106	....	....
2	Dewey	16 med. to poor hills—35 lbs.	....	....	6409	1522
1	Gov. Folk	13 good hills—67 lbs.	8176	1073	....	....
2	Gov. Folk	11 med. to poor hills—70 lbs.	....	....	7302	1546
1	Harvest King	5 good hills—32 lbs.	4780	1522	....	....
2	Harvest King	14 medium hills—62 lbs.	....	....	4108	1840
1	Ninety Fold	3 good hills—12 lbs.	5884	4178	....	....
2	Ninety Fold	8 medium hills—17 lbs.	....	....	4463	3151
1	Irish Belle	5 good hills—14 lbs.	3116	1919	....	....
2	Irish Belle	5 medium to poor hills—7 lbs.	....	....	1912	1619
1	New Late White Neb.	4 good hills—19 lbs.	12722	2586	....	....
2	New Late White Neb.	4 medium to poor hills—6 lbs.	....	....	7635	3226
1	Pingree	14 good hills—68 lbs.	12784	2054	....	....
2	Pingree	25 medium hills—75 lbs.	....	....	10765	1965
1	Snowflake Jr.	7 good hills—35 lbs.	7224	2195	....	....
2	Snowflake Jr.	7 medium to poor hills—19 lbs.	....	....	4294	2230
1	White Beauty	6 good hills—33 lbs.	6844	1403	....	....
2	White Beauty	10 medium to poor hills—34 lbs.	....	....	6328	1675
1	White Mammoth	13 good hills—	5790	1806	....	....
2	White Mammoth	24 medium to poor hills	....	....	4922	1843
		Average	8185	2015	6111	2458

Average gain of marketable potatoes per acre ....2074 pounds.

Table III—Second Year's Selected Seed and Results

No.	Variety	Tubers Selected	Product from good hills: Lbs per acre Marketable	Product from good hills: Lbs per acre Unmark'ble	Product from poor hills: Lbs per acre Marketable	Product from poor hills: Lbs per acre Unmark'ble
1	Beauty of Hebron	Good Hills	13694	2419	....	....
2	Beauty of Hebron	Common Seed	....	....	6832	5124
1	Carman No. 3	Good Hills	8286	1814	....	....
2	Carman No. 3	Medium to poor hills	....	....	3462	2233
1	Gov. Folk	Good Hills	6300	1369	....	....
2	Gov. Folk	Medium to poor hills	....	....	3457	1732
		Average	9426	1867	4583	3029

Average gain of marketable potatoes per acre..............4843 pounds.

The crop from the good hills not only was about one-third larger, but the tubers were more uniform in size and appearance than those from the medium to poor hills.

The medium and medium to poor hills, taken as a whole, were not as good as the careful farmer would take for seed from the bin, but he would be sure to get very little better. It has been the writer's purpose to select, for several years, the good hills for seed from the offsprings of the good hills, and the medium to poor hills for seed from the offsprings of the medium to poor hills, to show the cumulative effect of repeatedly selecting good hills; also to prove that potatoes "run out" by constantly taking for seed large and small tubers from the poor hills.

The varieties given in Table II are to be used to continue the experiment. This has been done for two years wtih three varieties and the results are given in **Table III.**

What to Look for When Selecting Hills.

When selecting potatoes in the field the farmer must have an ideal hill in mind for each variety and adhere strictly to that ideal when selecting. If one selects only large-yielding hills without taking other things into consideration, he will not attain the highest success. (See Table I.)

The following things should be taken into consideration:

1. **The number of plants to a hill.** It is not fair to compare a hill having two or more plants with another with one plant. It is better to compare hills having an equal number of plants and select the best. When a large piece having two or more eyes is placed in a hill, there are likely to be more plants springing from it than from a neighboring hill which received a smaller seed piece. The hill with many plants has just the same amount of space, plant food, and moisture that its neighbor has; therefore, it may not be able to develop all the tubers to marketable size, but only a small proportion of them. If all the many tubers in such a hill are uniform in shape and size and color, though they be a little under marketable size, they are better for seed than

the neighboring hill having one plant bearing one or two large tubers and other small, ill-shaped ones.

2. **The yield.** Other things being equal, the largest yielding hills should be selected.

3. **The shape.** We have varieties of all imaginable shapes but the shape desired by most markets is a slightly flattened round, oval, or oblong tuber. The tubers selected should have the variety characteristics.

Many claim that the tendency of tubers to become pointed or drawn out at the seed or stem end indicate lack of vigor. Mr. C. E. Flint of Blaine, Washington, says: "I have used the following plan for a few years and am sure it pays. I am careful to select only tubers that are full at the ends. I have followed this method with the "Rose," starting with seed that was about worthless. I have this year three rows thirty rods long, which yielded at the rate of five hundred bushels per acre."

Methods of Selection Used by Farmers.

Several successful growers west of the Cascade Mountains practice taking the tubers just below the marketable size from the good hills. When the crop is dug by hand this is a very good method.

Others who dig by hand throw two rows together and when a good hill is found throw all the tubers in the opposite direction, to be picked up separately for seed. The latter method is preferable except when cut seed is accompanied with danger of decay, because one can select closer since fewer hills will be required; and there is likely to be a tendency when the former method is employed to take medium sized tubers from hills that do not have ideal characteristics.

Many farmers in this state and in Michigan are practicing the above methods and they all say that they never expect to go back to the old method of taking seed from the general crop in the bin. One farmer in Michigan told the writer that he had practiced the latter method for four years and the fourth year

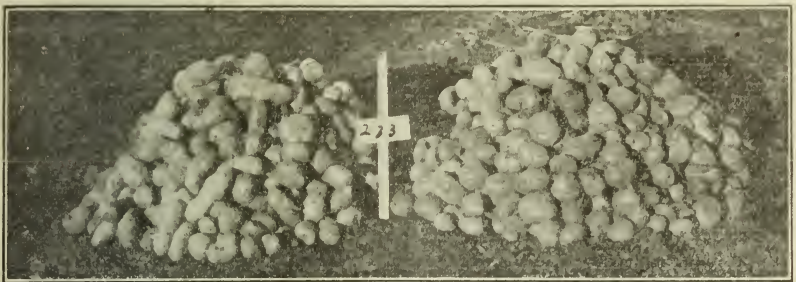

Fig 3. Variety—White Mammoth. Pile to right, from seleced hills. Pile to left, from medium to poor hills.

Fig. 4. Variety—Dewey. Pile to right, 7 good hills, weight 22 lbs. Pile to left, 18 poor hills, weight, 5 lbs. Note the difference in product, under the same condition of soil and care.

Fig. 5. Variety—Harvest King. Pile to the right, five good hills, weight 32 lbs. Pile to the left, 14 medium to poor hills, weight, 62 lbs. Note the large tubers in medium to poor hills, which would be taken in case large tubers were selected from the bin.

the seed selected in the field averaged fifty bushels per acre more than the bin selected seed.

Neither one of the above methods can be practiced where labor is high and a horse digger is used, but practically the same results can be secured by the following method.

Selection Seed in Field When Horse Diggers Are Used.

For the sake of convenience ten acres is adopted as the area a man grows each year and harvests by means of a horse digger.

1. The first selection is made at large in this ten acre plot, a field large enough to afford abundant opportunity for choice of plants. Each hill in the field should be somewhat carefully examined, special attention being given to the vigor, freedom from disease, habit of the plant, etc., and a few of those which appear to be distinctly superior to the general crop are marked with small sticks.

2. Before the main crop is dug with the digger, each marked hill is dug separately by hand. Those hills coming up to the standard are taken for seed and all others thrown out.

3. Second year seed from the selected hills is planted alongside of the regular selected seed and given the same treatment. It is best to dig this plot of selected seed by hand and select the best hills, to continue the line selected, and take the balance of the tubers, large and small, to plant the main crop the third year.

Until the farmer definitely settles in his own mind the importance of selection, by differences in yield, he should plant at least a few rows of ordinary seed in the same field and give both the same cultural attention, and compare the yields obtained from line selected seed with ordinary seed. The comparison will show the great profit which may be securred from the extra expense of line selected seed.

If the farmer has been digging by hand and wishes to get a digger, he may use one of the methods described above while he practices digging by hand. He will then have good selected seed to start with when this method is to be practiced.

Other things being equal, the closer the selection is performed the first year, the better the results that will be obtained in subsequent years. If the farmer is an expert at picking out the best hills before they are dug, the small plot may also be dug with the digger, after the best hills are taken out to continue the line of selection, thereby reducing the hand digging to a minimum. Only after long experience can a person become an expert at telling from the appearance of the plant what is likely to be in a hill. Plants should be vigorous and healthy, but on account of the great number of varieties it is impossible to give a rule to be followed in all cases.

SUMMARY.

1. Large areas of the state have climatic conditions particularly adapted to the growth of potatoes. The soil in these districts, if properly handled, is of such a character that it will hold enough of the winter and spring precipitation to manure a large crop of tubers without the help of rain during the summer season. The dry atmosphere is unfavorable for the development of the worst diseases of the potato. The Colorado beetle (Potato bug) is rarely found in this state. The long bright days of summer are particularly favorable for the formation of starch, which is the main solid constituent of the potato.

2. A deep, friable, mellow loam, rich in humus and well drained, is the ideal soil for potatoes. Heavier soils may give good yields, provided manure is well incorporated into it or green crops are plowed under. For the best results the physicial condition of the soil should be perfect.

3. Barnyard manure is the best fertilizer and may be applied in large quantities, provided it is well composted and worked into the soil.

4. Potato land should be plowed in the fall, left rough all winter, and harrowed thoroughly as soon as dry enough in the spring. Deep plowing is more satisfactory than shallow plowing. When spring plowing is practiced the harrow should immediately follow the plow.

5. Harrow thoroughly right after the potatoes are planted and at intervals of a week or ten days until the plants are from two to five inches high. Maintain a dry surface mulch with cultivator.

6. Level culture throughout the season is best. Hilling should not be practiced except on very wet, low land. The sunburning of potatoes can be avoided by planting deep and placing the hills close together.

7. The dry soil mulch is just as good and much cheaper than a straw or litter mulch.

8. The time of planting should be governed largely by the climate and object for which the crop is grown. Potatoes should be planted at a time which will bring the blossoming period when there is ample moisture. When new potatoes are desired early they should be planted as early in the spring as the soil will permit, on light, warm soil. When late potatoes are desired they may be planted as late as the middle of June, provided the supply of moisture is continuous and ample, but in sections where the summer rainfall is slight the earlier all crops of potatoes are planted the better.

9. There are several methods of planting potatoes. On a small scale the most satisfactory method is to drop and press the seed in the bottoms of furrows made by a plow or single shovel and cover them with a plow, single shovel, or harrow. The horse planter is satisfactory when large areas are planted.

10. The amount of seed to use and distance apart should depend upon the fertility of the land and supply of moisture. Rich soil with a continuous and ample supply of moisture should receive more seed and the hills should be closer together than on soil lacking one or both of the above characteristics.

11. The size of the seed piece should be uniform, regardless of the number of eyes.

12. The depth to plant depends upon the texture of the soil and whether early or late potatoes are desired. Five inches is none too deep for the late crop, on light mellow soils, but three or four inches is better for very early potatoes. Five inches is too deep on very heavy or very moist soil.

13. New potatoes can be got earlier by allowing the seed to sprout in strong light before planting.

11. A poor stand may be due (1) to the heating of seed after cutting, if sacked or piled up for more than six hours; (2) to diseased seed; (3) to planting early in wet, cold soil: (4) to chilled seed; and (5) to late planting on soil that has dried out.

15. There are several methods of harvesting practiced in the state. Digging by hand on small acres is most satisfactory, but for large areas the horse digger is almost indispensable.

16. More attention should be given to the proper grading of the tubers. Well graded potatoes bring a larger price than poorly graded ones. New early potaoes should be washed and packed into boxes for the best markets.

17. Potatoes are easy to keep in this state. They will keep in pits on well drained land if covered sufficiently to keep frost out, or in any frost-proof, cool, moist, but not wet storage.

18. The potato is one of the best crops to grow as a substitute for summer-fallow. The weeds are killed and soil is left in the best condition for wheat.

19. Enormous yields of potatoes can be secured under irrigation, provided the moisture in the soil is uniform and continuous.

20. All samples of seed of a given variety are not of equal value. A person should have an ideal in mind when selecting a variety.

21. The following varieties produce new potatoes early and mature early in the season: New Queen, Peck's Early, Pride of the South, Irish Cobbler, Early Ohio, White Ohio, Six Weeks, New Early Standard, King of Michigan, New Century, White Star, Early Thoroughbred, New Climax, and Early Rose.

22. The following varieties produce new potatoes early and mature in early September: Sweet Home, Champion of the World, Early Excelsior, Rural Red, Crine's Lightning White Victor, Early Hamilton and White Rose.

23. The following varieties produce new potatoes early but mature late: Burpee's Extra Early, Arcadia, Bevee, Early Jewel, Algoma, and Crown Jewel.

24. The following varieties produce good marketable tubers and ripen early in the fall: American Wonder, White Lily, Carman No. 1, Pink Eyed Seedling, Green Mountain, New Bur-

bank, Netted Gem, Sir Walter Raleigh, Vermont Gold Coin, and Washington Wonder.

25. The followin gvarieties yield a large crop but mature late: New Late Nebraska, Burbank, Gov Folk, Peerless, Ross Favorite, Rural New Yorker No. 2, Snowflake Jr., Carman No. 3, White Beauty, White Mammoth, North Pole Easterly, Harvest King, Great Divide, and North Pole Stinnett.

26. The following varieties are undesirable for market purposes, but advantageously grown for stock feed: Johnson's Seedlings, Purple and Gold, Pingree, Red Jacket, and Empress of India.

27. Potato seed should be selected in the field.

STATE COLLEGE OF WASHINGTON
AGRICULTURAL EXPERIMENT STATION
PULLMAN, WASHINGTON

INVESTIGATIONS CONDUCTED AT
WESTERN WASHINGTON EXPERIMENT STATION
PUYALLUP, WASHINGTON

Chou Moellier or Marrow Cabbage

By W. H. LAWRENCE

Bulletin No. 95

1910

All Bulletins of this Station sent free to Citizens of the State on application to the Director.

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CHOU MOELLIER OR MARROW CABBAGE

BY W. H. LAWRENCE.

The prevailing high prices for feed for dairy cows have made the search for new and promising varieties of forage plants a most desirable line of work. Of the many kinds of plants which might prove to be of value for hay, ensilage or soiling, which have been given a trial, none have given greater promise than the Chou Moellier, or Marrow Cabbage. Some information concerning the plant, considered to be of much interest and value to the dairymen, is herewith given.

HISTORY OF THE PLANT.

During early spring of 1909, Mr. J. G. Hopkins, of Tukwila, Washington, very kindly enclosed, in a letter to the writer, a newspaper clipping taken from an agricultural journal (the name and date of which cannot be given) headed, "Notes from the Channel Islands." The notes given were concerning Marrow Cabbage, which are quoted below.

"Within the last two months an Agricultural School has been opened in Guernsey by the 'Brothers of the Christian Schools,' * * * These 'Freres' have just introduced a new cattle fodder to the island, which is known as 'Chou Moellier' or marrow cabbage. This is the result of their own hybridization and experiments with Kohl Rabi, Kale and the Jersey 'chou'. The latter is the tall 'butter leaf' cabbage which grows to a height of from ten to twenty feet, according to seasons, etc.

"The Chou Moellier was first shown at the Chrysanthemum Show in Guernsey, November, 1905, and since that time it has rapidly grown in local public favor. Some of the farmers here have pricked out as many as 10,000 plants. Seed is sown about May and in the end of June the seedlings are moved to permanent quarters. The Chou stands all through the winter, being perfectly hardy both in the Channel Islands and in Brittany, and I should imagine as far north as the Midlands they would stand an average winter. There are two special qualities which make the new fodder valuable: first, its great weight; secondly,

its feeding qualities during the periods of drought when there is a general shortage of food. I have recently seen stalks cut weighing 18 pounds, all of the best cattle feed with no waste of any kind. In height, the stalks average from four to five feet, and they are from five to six inches in diameter. I have, however, seen some six feet in height and two feet in circumference. The stalk is of solid but sweet and juicy 'pith' or marrow, hence its name. There is no hard, woody or fibrous bark such as the ordinary cabbage stalk possesses. Chopped up, the cattle consume it with avidity; indeed, in the stock yard I have seen them turn from mangold and beet and parsnips to feed on the chou. As a milk producer, it is about equal to parsnips, and it does not give the objectionable taste to the milk and butter which parsnips do. Experiments have proved the new plant to be very valuable as a butter producer. A full sufficiency of heat is engendered by the chou moellier, but what constitutes one of the leading qualities is the fact that the farmer can pull an abundance of excellent leaves during the summer and autumn. As the cabbage grows, the lower leaves are pulled regularly about once a fortnight. At Les Vauxbelets of about an acre, the Freres were gathering a van load of the long leaves every day through the long drought. When all other farmers were complaining of a shortage of green food and consequently of milk, the Vouxbelets cows were yielding the usual quantity. Indeed, during the driest of the summer, one cow was giving from 24 to 26 per cent. of butter. The plants have been grown about 13 or 14 inches apart and 2 feet between the rows, thus giving each other support, as they are now standing on a very exposed part of the estate. The new food ought to be shown at some of the agricultural shows, and would, I believe, very favorably impress both farmers and breeders. The young tops are used by the Freres for their usual cabbage soup."

Believing that this forage plant would prove to be of value in Western Washington, and particularly so in the Puget Sound country, a communication, including an order for a small number of seeds of this plant, was sent to the Agricultural School. The correspondence, which is interesting as well as very instructive, was as follows:

"PUYALLUP, WASH., Jan. 14, 1909.

"*Agricultural School, Guernsey, England.*

"DEAR SIRS: I have read with a great deal of interest a short article on Chou Moellier or Marrow Cabbage, which appears in a newspaper clipping sent me by one of my correspondents. I have charge of the introduction and testing of various fodder crops for the western part of the State of Washington. This part of the United States is a most excellent agricultural region and is especially adapted to dairying. I am very desirous of determining the value of the marrow cabbage in this section. You certainly have a most desirable forage crop and I have no doubt that it will prove to be of much value in this climate. Will you kindly send me about 250 or 300 seeds, if you are able to spare

them. Of course I shall gladly pay you for the seeds. As I do not know the value, I am taking the liberty of asking you to send them and at the same time to include your bill.

"Thanking you in advance for any information you can give, and also thanking you for any favors you can show me concerning the Marrow Cabbage, I remain Very resp'y yours,

"W. H. LAWRENCE, *Superintendent.*"

The following is the reply to the above communication:

"THE VAUXBELETS AGRICULTURAL SCHOOL,
"GUERNSEY, Feby. 7, 1909.

"*W. H. Lawrence, Esq.*

"DEAR SIR: In reply to yours of the 14th ult. I have the pleasure of sending you some 500 seeds of the Marrow Cabbage and hope you will give it a fair trial. It is considered here a wonderful cropper, and can compete with any fodder crop both as to quality and quantity—at least under British climate.

"This cabbage is sown about the end of March in a seed bed and transplanted end of June on good and well manured soil, two feet apart every way. In September, the bottom leaves can be pulled and given to cattle till about Christmas, when the stocks are cut in succession as needed. The stock is quite tender and forms the crop proper; it is from 4 to 5 ft. high, weighing from 14 to 20 pounds each. They may be given to cattle, sliced either with the slicer or with a knife. Cattle eat them with greediness, as they are not watery like mangels. We are well satisfied with this fodder, which does not freeze in our climate. We cut it only when wanted.

"I hope the plant will do well with you and when you have tried it, be kind enough to let me know what feeding value you find it. You are quite at liberty to spread it, if you thing it a paying crop.

"I do not charge you for the seeds, being but too glad to help my fellow agriculturists in any way in my power.

"Hoping, dear sir, that your experimental station will be a source of improvement for the future of agriculture, and wishing you great success, I remain Faithfully yours,

"B. ANANIAS."

PROPAGATION.

During May, seeds of Marrow Cabbage were planted in flats in the greenhouse. From the time the young plants appeared above the surface of the ground until they were transplanted in the field they were given the same care that is necessary to successfully grow cabbage and Thousand-Headed kale. Seeds were also sown in drills in the field. As soon as the plants in the flats and in the garden were large enough to transplant

they were set in rows in the field. At this time they were four to six inches in height. They were set eighteen inches apart in rows forty inches apart. The usual method of transplanting as recommended for Thousand-Headed kale and cabbage was followed.

PREPARATION AND CULTIVATION OF THE SOIL.

A small field which had been utilized for a pasture for several years was plowed as early in the spring as weather conditions would permit, thoroughly disked and harrowed, in order to put the soil in good mechanical condition. A small plot of light, sandy loam, which had been utilized for farm purposes for more than forty years, plowed during the fall and again during the spring, was also prepared for this crop. The ground was not given any special attention other than plowing and harrowing necessary to put it in tillable condition. A black, prairie loam soil, underlaid with gravel, was also fitted for a limited number of plants. The fourth type of soil selected consisted of a mixture of clay and sand, containing considerable humus. This soil is very mellow and easy to till. In the preparation of this soil, the ground was plowed eight to ten inches in depth, thoroughly disked, planked, harrowed and disked, in order to make it loose and mellow. Furrows six to eight inches in depth, averaging five rows to the rod, were made with the plow. Well decomposed barnyard manure, consisting of a mixture of horse, cow, goat and chicken manure, was scattered in the trenches. The field was then planked and harrowed crosswise in order to cover the compost with dirt to a depth of two to three inches. The plants were then set in rows above the compost. As soon as they overcame the wilt and the ground was in good condition for tilling, shallow cultivation was given, in order to stir the surface soil and finish filling the shallow trenches in which the young plants were standing. Surface cultivation was given as frequently thereafter as necessary to keep the surface soil loose and mellow until the tops were too large to admit of further cultivation.

CHARACTERISTICS OF THE PLANT.

This hybrid, like many other hybrids, shows a very great variation in individual plants. There are all sorts of intermediate forms between a good type of Marrow Cabbage and Thousand-Headed kale. Very fortunately, however, a large per cent. of the plants were true to type. As soon as the seedlings overcame the wilt, they made a rapid growth. During their early growth they cannot be distinguished from Thousand-Headed kale plants with any degree of accuracy. Later, however, the stem begins to show a marked increase in diameter. After the plants attain a height of eighteen inches to two feet, they show their true characteristics.

Among the illustrations, Figure C and Figure E show that the plants when about three feet in height are destitute of leaves from the base one-third to one-half their height. At this time five to ten leaves have been removed, leaving large scars on the stem. As a plant grows, the leaves nearest the ground mature very rapidly, and, if not gathered, will fall off and decay. A few days after a leaf is mature it begins to turn a light yellow color. At first the color is very indistinct but gradually increases until it is very conspicuous, at which time the leaf separates from the stem, leaving a large scar. The falling of the leaves as they mature is identical with the falling of the leaves of all decidious plants occurring at the close of each year. It is found advantageous to remove the lower leaves frequently, in order to collect the mature ones before they begin to change color. When mature, the leaf will separate from the stem when a slight downward pressure is exerted on the stalk of the leaf near its base. The break is clean, leaving a perfect scar, since at this stage the leaf is only attached to the stem with a few fibrous strands. It was observed that by removing the leaves as soon as mature, a plant will make a more rapid growth than when such a practice is neglected. It is also noticeable that a very large weight of forage is lost if such a method is not practiced.

The general shape of the stem may be noted by referring to

the figures in the plate which appears in the bulletin. It is also observed that the leaves are of very large size. Many of them grow from 24 to 36 inches in length, varying up to 14 inches across the blade. The stalks of the leaves are also very large. The plant in Figure C stands about four feet in height. The plant in Figure B stands more than six feet in height. The latter plant has a circumference of between 13 and 14 inches. Other plants between four and five feet in height measured somewhat larger in circumference—measuring as much as 18 inches at the largest place.

The remarkable thing concerning this plant is the proportion of succulent feed which it contains. The stem is easily cut off at the base by using a small pocket knife. The outer portion is covered with a rather thick epidermis. The portion which corresponds to the bark of most plants is thick and fleshy. The woody portion consists of a very narrow layer, which is represented in Figures A, D and F as a dark line near the outer edge, and is very thin, composed of a series of interwoven strands. The inner portion, which is somewhat lighter in color, consists throughout of a very rich, succulent meat of excellent flavor, resembling that of Kohl Rabi. As shown in the same figures and especially in F, the central portion of the stem consists of a cavity of variable diameter. The flesh is more or less fissured, and especially near the upper end of the stem. The relative proportion of the meat, as compared with the woody portion, is best observed in the four cross sections of a stem, as shown in Figure F. The dark-colored, irregular and very narrow ring represents the woody portion. The portion lying outside of the wood consists of bark. The portion lying within consists of pith or marrow. The central, irregular portion represents the cavity of the stem.

VALUE AS A FORAGE PLANT.

The value of Marrow Cabbage as a forage plant has been discussed at some length in the above correspondence. At this station during the year as the lower leaves matured they were pulled and fed to the chickens and to the dairy cows. This

green stuff is greedily eaten and was apparently keenly relished in all of these feeding tests. In a later test, a few stems were collected and fed to the cows. They were eaten greedily. No ill effects followed feeding. There was no appreciable effect on the quality and quantity of the milk and butter. At the time these plants were fed, they were substituted for Thousand-Headed kale in the daily ration. It is believed that this plant can be grown for an early autumn forage as advantageously as Thousand-Headed kale.

COMPARATIVE YIELDS.

From the experiments conducted in growing Marrow Cabbage and Thousand-Headed kale under exactly the same conditions on different types of soils, the conclusion is drawn that Marrow Cabbage makes a more luxuriant growth and produces a heavier yield of green feed per acre. The results of the experiments on the light, sandy loam pasture land, the old sandy loam soil, and the black loam soil were about equally good. In the main experiments in which Thousand-Headed kale and Marrow Cabbage were started in flats in the greenhouse and in drills in the garden, transplanted at the same time on rich soil, prepared as described above and given precisely the same cultivation thereafter, Marrow Cabbage produced at the rate of 80 tons per acre, while Kale produced 66 tons per acre. It is evident from these tests that Marrow Cabbage will produce a heavier yield of succulent food per acre.

Since such a great variation in size of plants occurs, selection and breeding will no doubt produce a strain which will give a greater yield of fodder per acre than obtained in this experiment. Some plants grew to a very large size. The largest one weighed 18 pounds. At the time the plant was weighed, more than a dozen large leaves had been removed or had fallen off. A uniform stand of plants set two feet each way, each weighing 18 pounds, would produce a yield of 98 tons per acre. Even better results may be expected from Marrow Cabbage from home-grown seed.

HARDINESS OF MARROW CABBAGE.

In order to ascertain the hardiness of Marrow Cabbage, the plants were allowed to stand in the field until the middle of January, 1910. In the meantime, on several occasions, severe freezing weather occurred, during which time the thermometer fell as low as 14 degrees above zero. The effect of freezing on both Thousand-Headed kale and Marrow Cabbage was very marked. Many of the leaves of kale plants were badly injured or killed. Also some of the kale plants did not survive the lowest temperature. It is very evident that this hybrid resembles Kohl Rabi in its frost-resisting characteristics, since during this freeze a large number of Kohl Rabi, which had not been collected, were frozen and killed. More than three-fourths of the Marrow Cabbage plants did not survive. About thirty specimens, however, while injured slightly in most cases, were selected and stored for growing a crop of seed the following year. The object in allowing these plants to stand in the field during the winter was to study the effect of alternate freezing and thawing on the stems and leaves. It is evident that Marrow Cabbage cannot be grown and left standing in the field during the winter. It is believed, however, that by selecting the hardier plants and obtaining seed from them a strain can be developed which will stand as low a temperature as Thousand-Headed kale.

CHEMICAL ANALYSIS.

A chemical analysis of this plant has not been made up to this time. From the nature of the plant it is very evident that it is rich in protein and will compare very favorably with Thousand-Headed kale. In case a hardy strain can be produced which will stand as low a temperature as Thousand-Headed kale, Marrow Cabbage will no doubt replace the former in a limited way, especially in growing small amounts of green stuff for chickens. A few Marrow Cabbage plants would produce a very large amount of green stuff by giving the plants special care and by pulling the leaves at the right time, in order to encourage a more rapid growth of the stem and younger leaves.

LATER EXPERIMENTS WITH MARROW CABBAGE.

The Marrow Cabbage plants which have been stored, if they can be carried through the winter, will be "seeded" during the summer. If a supply of seed can be grown it will be ready for distribution during the autumn of 1910. Dairymen and poultrymen interested in procuring a few seed of this plant for trial may have the same on application to the Superintendent of the Western Washington Experiment Station

DESCRIPTION OF FIGURES IN PLATE.

Fig. A—One-half of a stem of marrow cabbage. The stem has been sectioned lengthwise.

Fig. B—A very large marrow cabbage, showing the characters of the stem. The leaves which have been badly damaged by alternate freezing and thawing have been reduced to stalks, bearing irregular-shaped fragments of the blades. The plant stood more than six feet in height. Notice the large scars on the stem caused by the leaves falling off during the summer and early autumn.

Fig. C—The same plant as shown in Fig. B when about four feet in height. The stick standing near the plant is three feet long. This illustration shows the nature of the leaf growth. The leaves vary up to three feet in length and are from ten to fourteen inches across the blade at the widest portion. Particular attention is called to the very large stalks of the leaves, which consist entirely of succulent forage. Note the scars on the base of the stem where several leaves have been removed previous to this time.

Fig. D—A stem of marrow cabbage with the leaves removed and sectioned lengthwise to show the general shape of the stem and the internal structure. The entire stem is edible. The woody portion, which is very thin, is represented by the dark line near the outer edge. The parts lying around the wood and enclosed by it are very tender and fleshy, resembling kohl rabi in flavor and texture. The stem is hollow, as shown by the irregular fissured central portion.

Fig. E—A general view of a few marrow cabbage plants as they appeared in the field when standing at a height of about three feet, as indicated by the yard stick leaning against the leaves of one of the large plants. The specimen against which the yard stick is leaning, while only three feet tall, measures nearly four feet across the top.

Fig. F—The longitudinal section of the stem with the roots attached as shown here is the same as Fig. D. The four cross sections show the comparative size and arrangement of the outer or bark portion, which is of a light color; the woody portion, which is represented as a very narrow and very irregular dark colored ring; and the marrow of the stem, which is very wide and somewhat lighter in color than the ring of wood. The irregular, dark, central portion represents the cavity in the center of the stem.


MARROW
CABBAGE
A
B
C
D
E
F

op
Stack

STATE COLLEGE OF WASHINGTON
AGRICULTURAL EXPERIMENT STATION
PULLMAN, WASHINGTON

INVESTIGATIONS CONDUCTED AT
WESTERN WASHINGTON EXPERIMENT STATION
PUYALLUP, WASHINGTON

Hatching and Rearing Turkeys by Artificial Methods

By H. L. BLANCHARD

Bulletin No. 96

1910

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HATCHING AND REARING OF TURKEYS BY ARTIFICIAL METHODS.

BY H. L. BLANCHARD.

INTRODUCTION.

Were we asked, which of the domesticated fowls of the United States is the most popular, our reply would be "The Turkey." The turkey ranks first among the fowls for Thanksgiving and the Christmas holiday feasts. Every family in the land would greatly appreciate a turkey dinner upon such occasions, yet, owing to the great scarcity and consequent high prices that invariably prevail, it has always been, and continues to be, impossible for the turkey producers to supply the demand, in any part of the country. The consumers throughout the Northwest, and in this state in particular, reluctantly are compelled to accept the cold storage article that is shipped into our state by the scores of carloads every year, or do without turkey for Thanksgiving dinner. The cold storage turkeys are much inferior in quality as compared with those direct from the farm, which fact is becoming understood by the consumer, hence the demand for turkeys is not growing as it would grow could the consumers get what they want in this line, namely, a fresh turkey direct from the farm.

Statistics show that the turkey production of the United States amounts to about one and one-half turkey per farm—only a few more than enough to supply the farmers themselves—yet more than three-fourths of our population live in the cities and towns and are non-producers of food products. It is safe to assume that at least nine-tenths of the turkeys produced are consumed in the cities and towns; thus a very large

percentage of those who produce turkeys (the farmer's family) go without turkey for Thanksgiving. They feel, owing to the high prices that the city folks are willing to pay, that they, themselves, cannot afford the luxury; hence, they sell off everything, retaining nothing in that line for themselves.

Such a condition is not necessary and ought not to be. There is no good reason why every family throughout our state, so desiring, should not have a turkey dinner for Thanksgiving and Christmas times, as well as upon other occasions.

Feeling that an experiment in growing a flock of turkeys practically in confinement, the past season at this station, will prove of great value to the people of our state, and the farmers in particular, this bulletin is being published that the information contained therein may become of practical use and value to our producers the present season, as well as for all time.

SETTING THE MACHINE.

About the first of June we secured 102 turkey eggs of the Mammoth Bronze variety, which nicely filled the tray of our 150 hen egg incubator. The machine had previously been warmed in the usual way, and at the time the eggs were placed in the tray the thermometer registered 102 degrees. The moisture pan, which was the same size as the tray and located beneath and two inches from the tray, was supplied with sand one-half inch in depth, which was thoroughly saturated with *warm* water. This sand was kept wet enough to show puddles of water on its surface at all times during incubation, by daily applications of water heated 100 to 103 degrees Fahrenheit.

TURNING THE EGGS.

The eggs were turned once every twelve hours—morning and evening—beginning on the third day after they were placed in the tray, and continued until the first sign of hatching, the pipping of the egg. The turning was very carefully done by first removing from the center of the tray about one dozen eggs, and then carefully rolling, with the hand, the remaining eggs toward the center of the tray—just enough to change the

position of each egg. The eggs that had been removed were then placed in either end of the tray.

TEMPERATURE.

During the first week a temperature of 102 degrees was maintained, and afterward 103 degrees, with but slight variations.

TESTING.

On the tenth day the eggs were tested for fertility, four clear eggs being found, which, with the three that were cracked in transit, left for the machine just ninety-five eggs. Of these, four more were taken out, at the second testing, which occurred on the twentieth day. Thus we had ninety-one eggs that had stood the test.

HATCHING.

The first evidence of hatching occurred on the evening of the twenty-seventh day, and by the evening of the twenty-eighth day the hatch was complete, resulting in 87 poults—four had died in the shell. The day following the hatch, the incubator door was left ajar about one-eighth of an inch, which was increased the second night to one-quarter of an inch. This was done to gradually harden the poults in their preparation for the hover.

BROODING.

During the afternoon of the second day after the hatch the poults were placed in a hover, in the brooder house. The hover had been warmed to a temperature of 90 degrees. The poults appeared well and bright. All were placed in one hover, which proved to be a mistake, for the following morning there were several dead ones, caused by the young things deserting the hover and piling up, many of the underneath ones being smothered. About thirty were thus lost in a few hours.

When reared in the natural way and seeking to be hovered, the poults instinctively duck their heads and creep under the mother hen, while she assumes a settling position. The poults having thus assembled they become distributed among the

feathers and under the wings of the hen. The warmth from the hen's body satisfies them. They become quiet.

Deprived of the mother hen they bunch when, in their search for warmth, a scramble ensues, each poult making a desperate effort to get under the bunch. In the struggle they become surprisingly entangled, causing a condition that brings death to the weakest ones from smothering.

In order to save the remaining poults they were divided among three hovers, which ended the losses. These hovers were at first kept at about 90 degrees temperature for about a week, when they were reduced in temperature about 10 degrees weekly, until down to 70 degrees, which temperature was maintained until the poults were about six weeks of age, after which time they do not require artificial heat. They were permitted to occupy the hovers for a couple of weeks longer, when the hovers were removed entirely. Care had been taken in keeping the hovers scrupulously clean, by removing the dirt and supplying clean chaff. After removing the hovers, the poults were confined to their nursery rooms, each four by twelve feet, with an outside runway four by twenty feet. It was found necessary to provide additional runways as they rapidly outgrew those they were occupying. At four months of age they were given their liberty. They would not range, nor travel but a few rods from the place where they had been confined.

FEEDING.

Unlike chickens, the young poults appeared not to know where to find their food. Teaching them to eat promised to become quite a problem. Failing to attract them to their feed in other ways, a few young chicks were placed in the nursery with each flock of poults. It was surprising how aptly they took their first lessons from the chicks. Within one hour the problem was solved and all were feeding and drinking, with no further trouble. The first feed was stale bread, moistened with sweet milk, chopped onion tops, grit and pure water. At this time the poults were nearly three days old. About three days

later their bread feed was gradually changed to commercial chick feed, cooked milk curds, and lettuce. Three or four days later there was added to this feed dry bran and beef scraps—five parts bran to one part scraps—mixed and placed within tneir reach in shallow boxes, which was kept before them all the time until they became five months of age. A convenient hopper for this dry bran feeding we find to be a box four feet long, six inches wide and six inches deep, with a strip two inches wide, nailed lengthwise and in the middle along the top. Supply this hopper daily, just enough for a single day's feed—all that the poults will eat. Fresh green stuff, such as lettuce, kale or cabbage, was fed liberally daily—morning, noon and evening; also sweet milk and fresh water. The drinking vessels were washed clean daily. A box of gravel and cracked shells and a dust bath were kept in their nursery. From the time they would pick up oats, corn or wheat their grain ration consisted of equal parts of these grains, mixed and scattered in the runway three times daily—as much but no more than they would eat. We regard that the most surprising thing in connection with the feeding was the small quantity of these grains consumed, which was evidently due to the very liberal supply of milk and green stuff provided.

PREPARING FOR MARKET.

Two weeks before these turkeys were to be marketed for the Christmas trade they were weighed separately, when one-half of the number were divided into lots of four each and placed in darkened pens—admitting the light only at feeding times—while the remaining one-half were confined in roomy roosting quarters, having a runway of 20 by 50 feet. These quarters were not darkened in any way. Both lots, in lieu of the mixed grain and dry bran feed, were fed three times daily of the following fattening ration—all they would eat—making the change gradually:

6 parts corn meal, 2 parts middlings, 2 parts beef scraps, by weight, and moistened with milk. The green feed was fed as before.

This experiment lasted two weeks. The birds that were confined in darkened pens made no gain whatever in weight, while those birds that had more liberty gained two pounds and two and one-half pounds each.

These birds were marketed when a little more than five and one-half months of age, when the pullets weighed 13 and 14 pounds each, and the toms 17 to 19 pounds each, live weight

THE STATE COLLEGE OF WASHINGTON
AGRICULTURAL EXPERIMENT STATION
PULLMAN, WASH.

INVESTIGATIONS CONDUCTED AT

WESTERN WASHINGTON EXPERIMENT STATION

PUYALLUP, WASHINGTON

ANTHRACNOSE OF THE BLACKBERRY AND RASPBERRY

By W. H. LAWRENCE

BULLETIN No. 97
1910

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ANTHRACNOSE OF THE BLACKBERRY AND RASPBERRY.

By W. H. Lawrence.

For several years the Snyder blackberry, which is grown extensively throughout the Puget Sound country, has not been producing good returns, on account of a greater or lesser per cent of the fruit failing to develop properly, for shipping or canning purposes. At the request of Mr. W. H. Paulhamus, president of the Puyallup and Sumner Fruit Growers' Association, the writer made a study of the trouble. The cause of the trouble and the method of preventing it have been determined. An account of the investigations, with recommendations, are herein given.

THE NATURE AND CAUSE OF ANTHRACNOSE.

This disease, which is commonly known by the popular name of anthracnose, is caused by a very small form of fungus (*Gloeosporium venetum*), consisting of two parts—the mycelium and the spores. The way in which the fungus passes the winter is not known. It probably lives in the canes and fragments of leaves that remain in the field after pruning is done. From field observation on the blackberry, the disease attacks the stems, leaves and fruit during the spring. The spread of the disease is caused by the distribution of the spores. Some of the spores lodge on the host plants. When the climatic conditions are favorable, the spores germinate and form the mycelium, which penetrates the tissue of the stems, leaves and fruit, causing spots on them. The mycelium soon gives rise to a large number of short branches just beneath the thin outer coat (epidermis). Spores are borne on these branches. When they form, they cause the epidermis to break open. These spores are held together by a mucilaginous substance which is soluble in water. In the presence of moisture, the spores are set free and are carried about by the wind and other agents. Some of them are sure to lodge on the various parts of the host plant.

KINDS OF PLANTS ATTACKED.

Among the varieties of blackberries, the Snyder, Kittatany and the Himalaya Giant are attacked. The Lucretia dewberry is also susceptible, while the Logan berry is by no means free from the disease. Of the red raspberries, the Antwerp is injured to a considerable degree, while the Cuthbert is but slightly affected. The Cumberland black raspberry and the Antwerp are equally affected.

Antwerp.—Anthracnose attacks the leaves and stems of this plant. The spots on the leaves are few and small, but not unlike those of the blackberry in general appearance. Those on the canes vary in size from minute dots to more than one sixteenth of an inch in diameter. A majority are well developed. They are much more conspicuous than the spots on the canes of other

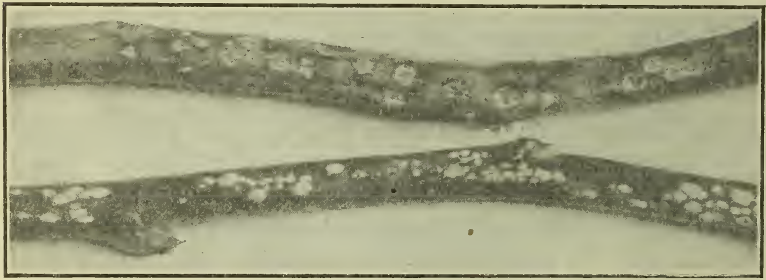

Fig. 1. Spots on the stems of an Antwerp red raspberry, caused by the anthracnose fungus.

plants mentioned. The central portions are light grey to white in color, the margin a reddish brown to almost black in color, while the infested area is shrunken, extending the greater part of the way through the bark. When they are abundant and close enough together so that they merge, large irregular cankers are formed. The disease is more abundant in old fields, in which place it usually does considerable damage.

Cuthbert.—The Cuthbert is only slightly susceptible to the disease. Only a few canes were observed with spots on them. A very few diseased leaves were collected. The spots are not unlike on the leaves and canes of the Antwerp.

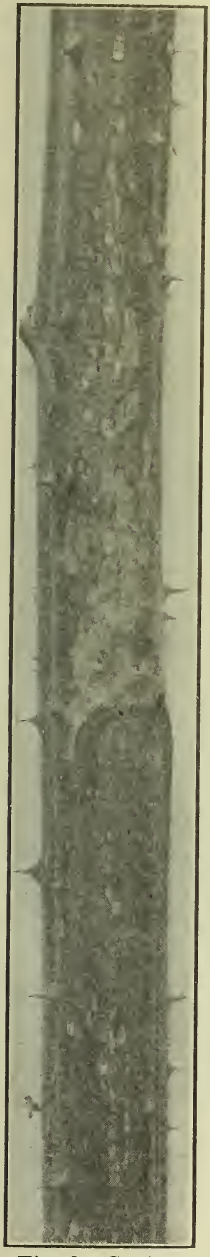

Fig. 2. Spots on the stem of the Lawton blackberry, caused by the anthracnose fungus.

Cumberland. — The Cumberland black raspberry in some fields is also badly infested with the disease. It is not unlike the same disease on the Antwerp in its general appearance and effect on the plants.

Snyder.—An examination of the whole plant (a hill), late in the summer, shows that not all parts of it are attacked. No new spots appear on the canes which bear the crop of fruit, or the branches produced during the first season. New ones are more or less abundant on the fruiting laterals which are produced the second season. All the leaves may be infested—those on the lower fruiting laterals and on the main cane and its branches particularly so. The shoots (new canes or current year's growth) are usually well covered with spots from a few inches from the base to a height of three to four feet. The smaller and younger spots are at the upper end. All of the leaves are usually also badly infested. Laterals on the new canes are free from the disease except at the very base. The leaves on these laterals do not become infested.

1. Disease in the Stem.—The spots in the stems are found to be elliptical in shape and have somewhat irregular margins. They vary in size from less to three or four times larger than a pin head—usually about twice as large. The center is a light grey to nearly white in color, while the margin is a deep brown. When these spots are mature in size they are sunken, and oftentimes split open length-

wise with the cane. They usually extend nearly through the bark. When abundant, irregular patches of considerable depth are formed, which act as a partial girdle on the stem.

2. Disease on the Leaves.—The spots in the leaves are round and smaller than those in the canes—usually about half as large as the head of a pin. The centers are nearly white in

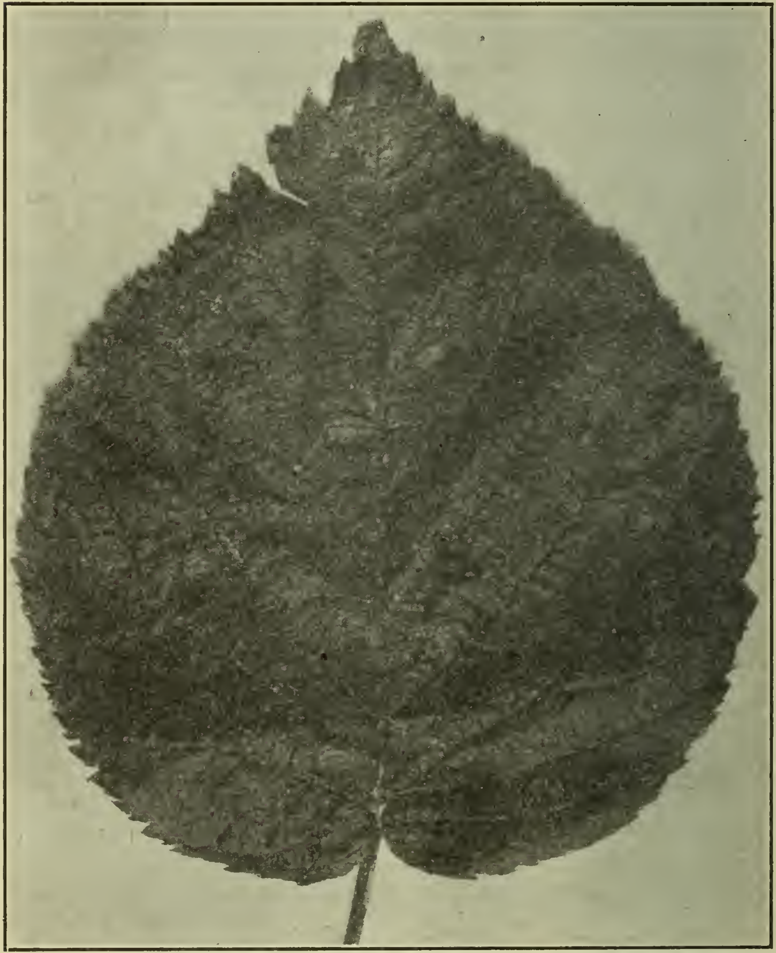

Fig. 3. A leaf of a Snyder blackberry, showing a large number of small spots in the leaf caused by anthracnose fungus.

color, while the borders are wider and of a reddish-brown color. These spots usually extend through the leaf, and when they are abundant run together, forming large patches. These dead areas drop out, leaving holes or slits in the leaves, causing them to appear as if whipped by the wind. The injury done the stem and leaves is very little as compared with the injury done the fruit.

3. Disease on the Fruit.—During the season, the latter part of which is unusually dry on the fruit which is constantly shaded, the disease is most abundant. The upper drupels* of the ber-

Fig. 4. Several Lawton blackberries badly infested with anthracnose. The healthy drupels are plump and smooth, while the diseased ones are dry and badly shriveled.

ries are also more often attacked. The diseased drupels also usually occur in clusters. The disease may attack the fruit at any stage of its development. The greater number become infested while yet green in color and sometimes when no larger than a pea. When the fungus attacks the fruit, it usually finds

*The fruit of the blackberry consists of a short, fleshy branch, bearing numerous small, fleshy fruits growing close together called drupels.

an entrance in the outer end of the drupel, usually near the style of the pistil. There is seldom more than one spot on a drupel. From one to many druples may be infested. Sometimes every drupel on a fruit becomes infested. Evidently on some fruits the infection takes place on nearly all the drupels at the same time, as the spots are all about the same size and equally well developed. On other fruits, the observations made seem to indicate that infection may spread from one drupel to another, since on some badly infested fruits the oldest infested drupels are at the center of the group. This seems to be true only for the more mature fruits. If this is true, the infection comes from spores produced on the drupel and not from the fungus growing from one drupel directly through into another. The fungus matures spores on some of the infested drupels by the time they are about to turn from green to red.

When young drupels become infested, a small brown dot appears on the surface on the end. These areas increase rapidly in size and soon involve the entire surface. In the meantime, the infested portion stops growing, the surface becomes rough and marked with nearly white lines, caused by the epidermis splitting open. As the fruit matures and the amount of water increases in them, the infested areas become more or less shrunken. The spot becomes deeper brown in color. The center of each may become white, owing to the development of masses of spores. At this stage the fruit is nearly red in color, and the spots are very conspicuous. Infested drupels on a well-matured fruit are of a dull reddish brown color. As the drupels mature, the proportion of water in the berry increases very greatly. If infection has taken place early in the season while the drupels are small and do not contain much water, they will remain firm and finally become dry. In case infection takes place when the drupels contain a considerable amount of water, however, they will crush very easily. Fortunately late infection is rather rare, as far as our observations go. A greater number of drupels on ripe fruit are dry enough so that they do not injure the shipping quality of the fruit. When the drupels become infested, the growth is only partially arrested. They continue to grow at the base and partially mature, but do not form a saleable berry.

Kittatany.—The disease attacks the Kittatany the same as described for the Snyder.

Himalaya Giant.—Of the Himalaya Giant the leaves are the only part of the plant that is susceptible. The spots are larger and more conspicuous than on the leaves of the other blackberries.

Lucretia.—The anthracnose on the dewberry (Lucretia) differs somewhat in general appearance and action from the same disease on the blackberry. The fruit very rarely becomes infested, while the disease is very marked on both the leaves and stems. The shoots, as well as the canes, are very badly infested on the stem, from a few inches from the ground to a height of two or three feet. There are few or no spots on the upper

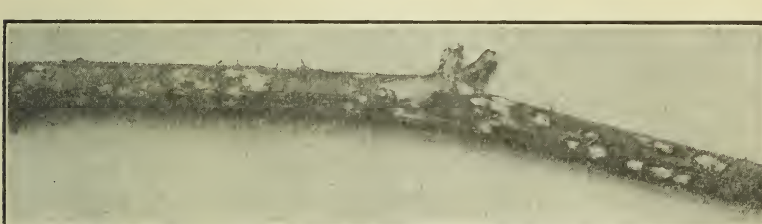

Fig. 5. Spots in the stems of a Lucretia dewberry, caused by anthracnose.

ends of shoots. It is also noticeable that the laterals of young shoots are seldom attacked. When so, the spots are very few in numbers and only grow to be about one-third as large as the spots on the main stem. On the old shoots all the leaves become badly infested, while on the new ones the stalks of the leaves may become well covered with spots, while the blades are entirely or nearly free from them.

The spots on the canes are sometimes so numerous and close together that they merge, forming large irregular patches. As a rule, however, they are well scattered. They are about two or three times as large as a pin head, round or oblong in shape, and somewhat depressed. The dead bark in these spots is nearly white in color and each is surrounded by a reddish-brown ring. Even the very small areas, when viewed closely, show the white center and red ring. These spots on the bright

green stems give the stalk a very conspicuous speckled appearance. On the leaves the spots are even more conspicuous than on the stems. On the more healthy leaves, the young spots are minute and reddish-brown, without a white centre. These older spots are markedly conspicuous on badly infested leaves that have become light yellow in color. This variety of berry plant is injured greatly by the disease.

EXPERIMENTS WITH ANTHRACNOSE.

Inoculation.—Diseased fruit was taken from the field and cultures made of all the bacteria and fungi found growing on it. The forms isolated (with the exception of the form, the spores of which resembled the spore of the fungus causing the disease of the stems and leaves known as anthracnose), grew readily and were soon available for inoculation purposes. The same plans in making the inoculation were followed as described for inoculation with anthracnose, as explained below. Pure culture of these organisms did not produce the disease on the fruit in a single instance.

Owing to the nature of the growth which anthracnose makes in culture media spores cannot be obtained in quantities for inoculation experiments. Cultures of spores from the stems, leaves and fruit, however, produced the same identical growth, showing that the spores are those of the same fungus. Since the culture gave evidence that anthracnose occurs on the fruit, inoculations were made, as described below.

Diseased berries in different stages of maturity, from green to ripe, in which spores of the fungus had not developed, were collected, immersed in fifty per cent alcohol for a few moments, after which they were thoroughly rinsed in sterilized water to remove the alcohol. These berries were then placed in moist chambers. In these cultures, the fungus in the fruit grew from the infested areas in tufted areas and in tufts, arranged in circles around the central portion of the diseased areas, or, in some cases, the rings were continuous, since the tufts were so numerous that they merged. The growth of the fungus in these cases can only be determined by using a lens, since the growth under the naked eye appears very much like a white residue of some salt deposited by the evaporation of water in which it

occurred in solution. The study of the fungus must be brief, since the threads collapse quickly in a dry atmosphere.

On July 20th, short fruiting laterals with apparently healthy berries were placed in water to keep them fresh. Small drops of water were placed on the drupels and spores of the fungus from diseased fruit were placed in them. At the end of fifteen hours some of the drupels, mature enough to turn black in color, showed signs of the disease. Other and younger drupels showed signs of the disease in twenty-four to forty-eight hours. About one-fifth of the inoculations took effect.

On the 26th of July, fruiting laterals from a patch of Snyder blackberries that had not begun to blight were placed in bottles containing water to keep them fresh. Each branch had berries in various stages of maturity from green to ripe. Drops of water were placed on the berries, and spores taken from spots in the leaves and stems of diseased Snyder plants were placed in them. At the end of a week when the fruit had become slightly wilted, numerous spots were found on the fruit in all degrees of maturity. From the general appearance of these spots and their effect on the fruit, it is evident that a majority of the spots on the fruit took effect shortly after the spores were placed in the water.

SPRAYING.

Potassium sulphide (one ounce to 2½ gallons of water), copper acetate (1 ounce to 8 gallons of water), ammoniacal copper carbonate (1 ounce to 16 gallons of water), and Bordeaux mixture were used in the preliminary tests. The object in using the former was to test the value of such sprays as would not leave a residue on the fruit. Poor results were obtained with all sprays except Bordeaux mixture.

How to Prepare the Spray.—Copper sulphate, 4 or 6 pounds; lime, 4 pounds; water, 50 gallons.

Bordeaux mixture is composed of a number of chemical compounds formed when solutions of bluestone and milk of lime are poured together. The chemical changes which take place are delicate, and in order that they take place correctly, the solutions must be diluted, and great care must be exercised in mixing. The method of mixing, as well as using dilute solutions, not only has an important bearing on the chemical, but also on the physical nature of the mixture. The most valuable com-

pound formed, and the one which is easily modified in the mixing, is a bluish, gelatinous substance that has about the same specific gravity as the fluid in which it is suspended. Of the different methods tried, the following has given the best results and is the only recommended:

Bluestone Solution.—To prepare this solution, the bluestone can be dissolved very quickly in a small amount of boiling water. Place the bluestone in a wooden vessel and pour the boiling water over it. Pour the strong solution in a barrel and add enough more cold water to make 25 gallons. The solution may also be prepared by placing the bluestone in a closely woven sack that will not lint, and suspending the same from a stick laid across the top of a barrel, so that the bluestone hangs just beneath the surface of the water in a well-filled barrel. When the bluestone is all dissolved, remove the sack and add enough more water to make 25 gallons of bluestone solution.

Milk of Lime.—To prepare the milk of lime, place 4 pounds of good quicklime (preferably large pieces) in a wooden vessel. Add enough water to wet it thoroughly. When it begins to dry and crumble, add more water. Be careful not to add enough to chill it or too little so that it will burn. When the lime has formed a good paste and is still slaking slowly, allow the slaking to continue and the paste to cool before adding more water. If this method is followed, a smooth paste, free from grit and small lumps of lime will be obtained, provided a good quality of lime has been used. Mix the paste thoroughly with 25 gallons of water.

Mixing.—To mix the solutions of bluestone and milk of lime, two men are required to do the work. Pour the two solutions slowly in such a manner that they mix in falling. If the solutions fall some distance, the churning motion caused by the falling column of water aids in mixing. After the solutions have been poured together, stir the Bordeaux thoroughly, using a wide, wooden paddle. After straining, the mixture is ready for use.

Testing.—The spray should be tested to see if enough lime has been used to unite with all the bluestone. Fill a shallow dish partly full of the Bordeaux mixture and add a few drops of a

solution of ferro cyanide of potash (one ounce to half pint of water). If a reddish-brown color appears, add more lime paste, stir thoroughly and test a second time. Continue to add small amounts of lime paste until the reddish-brown color fails to appear, when the test is made.

Stock Solutions.—When a large quantity of the mixture is needed, mixing is greatly facilitated by preparing stock solutions of both the lime and the bluestone. The best mode of preparing these is to fill a barrel partly full of water and suspend in it 100 pounds of bluestone. When this has dissolved, remove the sack and add enough water to make 50 gallons. You have then a solution in which two pounds of bluestone are dissolved in each gallon of water. Prepare a barrel of milk of lime in the same manner explained for slaking the lime. When this lime solution is stirred thoroughly, each gallon of water contains two pounds of lime. To make 50 gallons of the Bordeaux mixture, measure out three gallons of the bluestone solution and add enough water to make 25 gallons. Measure out two gallons of the milk of lime and add enough water to make 25 gallons. Stir thoroughly, pour the two solutions together, stir, test and strain, following closely the directions given above.

Applying.—In applying the spray, begin at the top of the plants and work downward, giving the canes a thorough coat, and wetting the entire surface of every leaf. Do not use too much spray or it will collect in large drops and run off and much of the value of the application will be lost.

CO-OPERATIVE EXPERIMENTS.*

Spraying experiments were conducted in co-operation with J. P. Gish and J. S. Friedley at Puyallup, and G. J. Anderson, Orton Bros. and W. H. Paulhamus at Sumner. Results have not been as gratifying as was hoped for, but are good enough to encourage the use of Bordeaux on an extensive scale.

Experiments in the Gish Berry Field, 1907.—Four rows of Snyder blackberries, each about 300 feet in length, were sprayed twice with 4-4-50 Bordeaux. The first application was made on May 4th, at which time the plants were nearly in full leaf.

*The writer wishes to acknowledge the assistance and hearty co-operation of Messrs. Gish, Friedley, Clark, Anderson, Orton Bros. and Paulhamus.

The second application was made on May 21st, just before the blossoms opened. Four rows of the same length were left as checks.

During the season, at three separate pickings, the fruit was sorted. This work was personally attended to by Mrs. J. P. Gish.* At the first picking, two crates from sprayed rows gave three-fourths of a box of blighted berries. The same number of boxes from rows that had not been sprayed gave one and one-half boxes of blighted berries. At the second picking there were ninety boxes on each of the sprayed and check portions of the field. Three-fourths of a box was discarded from the sprayed lot and five boxes from the check lot. The third time the fruit was counted, twelve boxes from check hills gave 195 blighted berries, and the same number of boxes from sprayed hills gave only thirty blighted berries. Sprayed portions gave per picking in order named: 1.5, 0.8, 1.0 per cent. blighted fruit. Check rows gave 3.0, 5.5, 8.0 per cent. blighted fruit.

Shortly following the spraying, the foliage of plants grown on sandy loam soil on sprayed rows for a time was a much deeper green than check rows. At picking time this difference was barely noticeable. The beneficial effect of spraying on the leaves was not noticed on plants growing in heavy soil. The fruit, however, on sprayed rows was larger and more glossy. There were among the unsprayed berries many that only had a spot or two of late infection that were not considered blighted but which were detrimental to the general appearance of the fruit. There were a few late infections on the sprayed berries. The blight increased during the season.

Experiments in the Orton Bros.' Berry Field, 1907.—The field of blackberries in which this experiment was conducted consists of Snyder and Kittatany. The greater portion of the plants are of the Snyder variety, with scattering hills of the latter variety. For two years the Kittatany had blighted much worse than the Snyder. In 1906 the field, with the exception of parts of three rows, each eight hills long (rows 7 feet apart, 6 feet apart in the row, hill system) were sprayed twice with 2-3-50 Bordeaux mixture on June 1st and 10th. When the

*Thanks are due Mrs. Gish for her hearty co-operation and the creditable manner in which the data from this experiment were recorded.

berries were gathered, those from rows which were not sprayed showed two to three times more disease than the fruit from sprayed ones.

During 1907 some of the rows were sprayed with 6-4-50 Bordeaux just before the leaf buds opened (last of March to first of April). Later, and just before the flower buds opened (about May 1st) a part of the rows were sprayed a second time with 4-4-50 Bordeaux. During the season no injury from the spray was noticeable, nor was there any beneficial effect on the plants other than the reduction of the amount of disease on stems, leaves and fruit, with the exception that the fruit on rows sprayed twice began to ripen a little earlier in the season.

Twice during the season a portion of the picking was sorted. Twelve boxes were picked from each of a check row, a row sprayed once and a row sprayed twice. The check rows (two) gave an average of 21% blighted fruit, the row sprayed once 7% blighted, and the row sprayed twice 2.5% blighted fruit. About two weeks later, a similar examination and count was made. The check row gave 37% blighted, row sprayed once 16% blighted, and row sprayed twice gave 8% blighted.

These figures show that two sprayings reduced the amount of blight more than two-thirds.

Experiments in the Anderson Berry Field, 1907.—At two dates during the picking season a small amount of the fruit was gathered and sorted from rows that had not been sprayed, rows sprayed once and rows sprayed twice. 4-4-50 Bordeaux was used. The first application was made when the plants were well leafed out and the second about three weeks later, before the blossoms opened. The first sorting of fruit showed 34% blighted fruit on check, 25% on rows sprayed once, and 16% on rows sprayed twice. A second picking a couple of weeks later gave 50% blighted on check, 33% blighted on rows sprayed once, and 20% on rows sprayed twice. These results also show that spraying reduces the per cent. of the disease and that two applications are more valuable than a single spraying.

Experiments in the Gish Berry Field During 1908.—In this experiment, the Snyder blackberry plants sprayed during 1907 were given a single application of 4-4-50 Bordeaux just before the fruit began to turn from red to black. The fruit was sorted

on August 11, 14, 17, 20 and September 1. The per cent. of diseased fruit on sprayed plants decreased from 29% to 12%, with an average of 20%, while the fruit on plants that had not been sprayed gave an average of 39% diseased fruit, varying from 29% to 42%. In the inspection of diseased berries it was also noted that there were three times as many diseased drupels on fruit which had not been sprayed than the fruit which had been coated with Bordeaux mixture. While late spraying reduces the disease, such a practice cannot be recommended, as indicated by the above data.

Experiments in the Paulhamus Berry Field, 1908.—A field of blackberries of the Snyder variety were sprayed twice with 4-4-50 Bordeaux. The first application was made just before the flower buds opened and the second when the fruit was about the size of a field pea. Notes on the condition of the fruit were first taken during the fifth picking on August 15th. An average of twelve boxes of each of sprayed and unsprayed fruit was gathered on August 15, 16, 19, 21, 23 and September 2. After the first picking the per cent. of blighted fruit gradually decreased from 42% to 11%. The average of diseased fruit was 23%. The diseased fruit on plants that had not been sprayed gave an average of 46% diseased fruit. In this fruit there was also a gradual decrease in per cent. of diseased fruit from 61% to 27%.

As indicated by the data, Bordeaux is a valuable preventive against this disease. Again, as has been pointed out above, there was a marked difference in the number of diseased druples on sprayed and unsprayed fruit. There was a much larger per cent. on the unsprayed fruit.

Experiments in the Friedley-Clark Berry Field, 1908.—A few rows of the Lawton blackberry were sprayed with 4-4-50 Bordeaux, when the fruit began to change from red to black. The berries were inspected on August 10, 14 and 22. The sprayed rows gave 35% diseased fruit, while the unsprayed rows gave 49% diseased fruit. There was an increase of 10% in the disease on unsprayed fruit during the twelve days.

Another field of Lawton berries were sprayed with 4-4-50 Bordeaux. Two applications were made. The first was applied just before the blossoms began to open and the second

just before the fruit began to ripen. The berries were inspected on eight different days from August 3rd to August 23rd, inclusive. There was an average of 29% diseased fruit on the sprayed row and 41% diseased fruit on the checks.

A few hills of Kittatany plants were sprayed twice, in the same manner as described for the Lawton. Three inspections were made (August 3, 10 and 13). Sprayed fruit gave 30% diseased fruit, while the unsprayed gave 40%.

During all these inspections it was to be noted that the number of drupels on diseased fruit from sprayed plants were less numerous than those on diseased fruit from unsprayed plants.

CONCLUSION AND RECOMMENDATIONS.

1. Anthracnose is caused by a small form of fungus.
2. Distribution of the fungus is accomplished by the spores.
3. Anthracnose attacks the Snyder, Kittatany and Himalaya Giant blackberries; the Lucretia dewberry, Logan berry; Antwerp and Cuthbert red raspberries, and the Cumberland black raspberry.
4. The disease is very injurious to the Snyder and Kittatany blackberries, attacking the stems, leaves and fruit.
5. A microscopic study and inoculation experiments show that the same fungus occurs in the spots on stems, leaves and fruit.
6. The fungus attacks the current year's growth of shoots, when they are six inches to one foot in height and later. Spots do not occur on the bases of these shoots.
7. The disease does not spread on the stems and its leaves after the branches form, since the canes and its leaves are infested, while the laterals and their leaves are usually free from the disease.
8. On the Snyder and Kittatany blackberries the fungus spreads from the stems and leaves to the fruit as soon as the young fruit forms.
9. The disease continues to spread on the fruit during the entire season. The fruit is damaged more or less severely, depending on date of infection and the number of drupels on each berry that become diseased.
10. The fungus probably lives over winter in the berry field in the leaves on the ground and in the canes.

11. To check the ravages of the disease destroy the infested leaves and cut out badly diseased canes and shoots before the leaves fall off, and be sure to burn them. In order to kill the spores of the fungus on the canes, spray with 4-4-50 Bordeaux mixture before the leaves appear. In order to protect the leaves and young canes the plants should receive a second application of Bordeaux, when the leaves are well out and by the time the young shoots are six inches in height. A third application should be made just before the blossoms appear.